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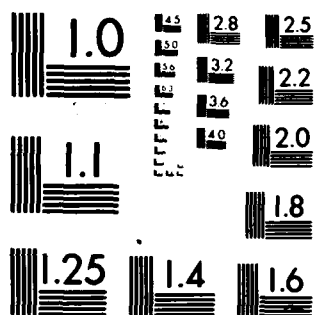
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| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number) A hierarchy of computer programs implementing the method of moments for bodies of translation (MM/BOT) is described. The algorithm treats the far-field radiation and scattering from finite-length open cylinders of arbitrary cross section as well as the near fields and aperture-coupled fields for rectangular apertures on such bodies. The theoretical development underlying the algorithm is described in Volume I of this report. (Cont'd) | | |

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Item 20 (Cont'd)

The structure of the computer algorithm is such that no a priori knowledge of the method of moments technique or detailed FORTRAN experience are presupposed for the user. A set of carefully drawn example problems illustrates all the options of the algorithm. For more detailed understanding of the workings of the codes, special cross referencing to the equations in Volume I is provided. For additional clarity, comment statements are liberally interspersed in the code listings, summarized in Volume II. *the present volume*

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1. INTRODUCTION

This manual is divided into two parts. Section 2 constitutes the user section, describing the overall flow of the codes, input data requirements, and parameter relations. At the end of the section, a series of sample problems is given to illustrate the use of the codes. Sample problem 1 exercises all parts of the computer algorithm and serves as a check case for the installation of the codes on a given machine. Section 3 provides a detailed description of all the codes and subroutines. The user need not make reference to Section 3 or to the analysis in Volume I of this report to successfully install and execute the algorithm on a particular computer system.

A brief synopsis of the main program features and options are listed below:

Flexible body geometry - The algorithm can treat a finite-length BOT of any asymmetric cross section. The analysis assumes that the body is open on the ends. Certain degenerate forms of the BOT configuration have also been analyzed with this algorithm such as flat plates, parabolic and square cylinders.

Arbitrary antenna placement and excitation - The algorithm treats single or multiple rectangular aperture (slot) antennas embedded in the BOT surface. Location of the antennas can be anywhere on the BOT. Spacing between adjacent apertures can be electrically small. All apertures can be asymmetric.

Surface currents - The algorithm outputs the surface currents on the BOT surface in spatial and modal form. Both the magnitude and the phase of the t - and z -directed components are given.

Choice of polarization and radiation planes - The radiated fields and the power gain, normalized to an isotropic radiator, are given in the user-specified planes for θ and ϕ polarization.

Arbitrary choice of sampling points for near fields - The electric and magnetic fields (six components in all) resulting from currents induced by antennas on the BOT or by incident fields are computed at user-specified points in the vicinity of the BOT surface.

Calculation of aperture-coupled fields - All the field components for the electromagnetic waves penetrating a passive rectangular aperture on the BOT are computed at user-specified sampling points. The size and location of the aperture are also user specified.

The foregoing features of the algorithm are demonstrated in the sample problems of Section 2.6. These features have been tested, and the corresponding results are in good agreement with available data. As in all modeling, caution must be exercised in applying this analysis to certain problems such as the computation of the edge diffraction from the BOT ends and the fields coupled through small apertures. To achieve sufficient accuracy, a large number of modes may be necessary in these problems.

2. USER SECTION

The MM/BOT computer codes are written in FORTRAN IV, consisting of five main-line programs (i.e., BOTZSS, BOTINV, BOTRA, BOTSCM, and BOTSCB) and one small utility program (BOTSEG) as shown in Figure 1. The five main-line programs use the same coordinate data file with minor deletions, depending on which of the above programs are run. In addition, two binary disk files, ZBOT and YBOT, are generated by the programs BOTZSS and BOTINV. All the programs have user-oriented inputs, which can be easily generated for a given problem. Examples demonstrating the input data requirements are discussed in Section 2.6.

2.1 Implementation of Computer Codes

All of the BOT computer codes are written in USA Standard FORTRAN IV, with the exception of end-of-file (EOF) checks in programs BOTINV, BOTRA, BOTSCM, and BOTSCB. The EOF checks given in the listings in Appendix C are specific to the compiler used in the program development (i.e., CDC CYBER 175 system). The functioning of the EOF checks in the present listings is as follows:

IF (EOF(u)) a,b

u - unit number to check.

a - statement label to branch to if an EOF is encountered.

b - statement label to branch to if an EOF is not encountered.

This EOF check occurs in the listings (Appendix C) at the following places:

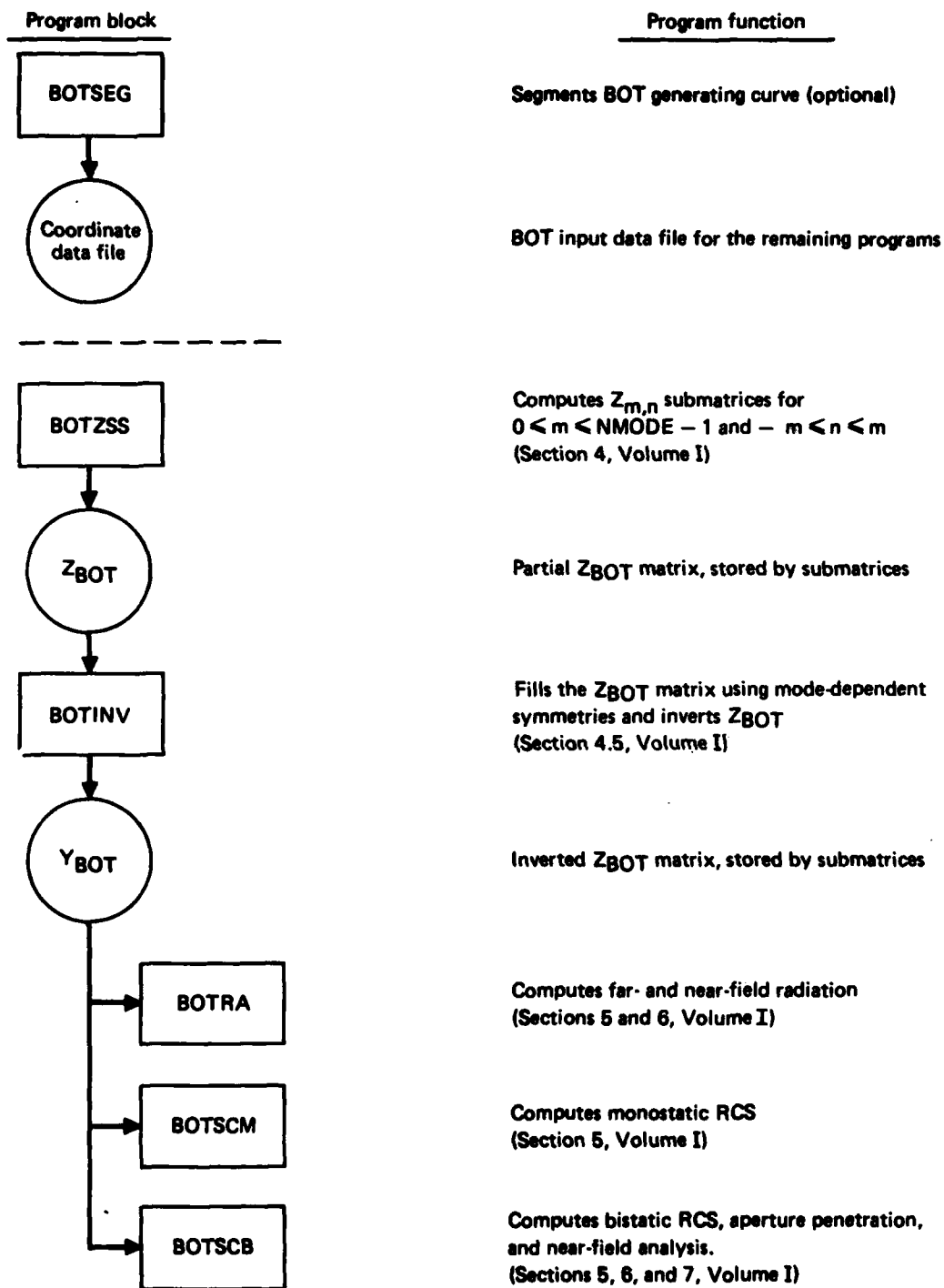
| | |
|--------|---|
| BOTINV | line numbers 480, 1310, and 1870 |
| BOTRA | line number 1500 |
| BOTSCM | line number 1300 |
| BOTSCB | line numbers 1330, 2125, 8310, and 8970 |

The device unit numbering convention is as follows:

unit number 5 - card reader

unit number 6 - line printer

unit number 1 - binary input disk file containing alternating records of lengths 2 and $2(NP-3)^2$ words, respectively. NP is the number of data points describing the BOT generating curve discussed in Section 2.2.



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Figure 1. Overall flow diagram for MM/BOT algorithm.

unit number 2 - binary output disk file containing alternating records of lengths 2 and $2(NP-3)^2$ words, respectively.

2.2 BOTSEG Description

BOTSEG is a utility program, which can be used to segment the BOT generating curve using a limited set of data points (see coordinate geometry in Figure 2). The required input data and formats are described below.

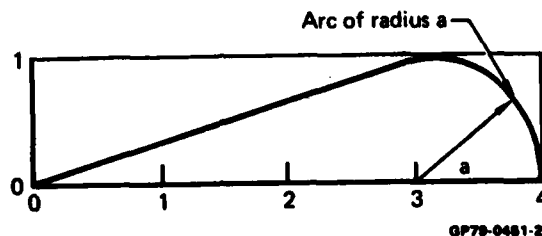


Figure 2. Representation of a BOT with a cross section formed by a wedge and arc segment.

```

READ(5,1)NPTS,NP
1  FORMAT(2I3)
    NPTS - Number of input data points used to describe the BOT generating curve.
    NP - Number of equally spaced BOT generating curve data points to be calculated. (The calculated data are used as input to the remaining BOT programs.)

DO 100 I = 1, NPTS
100 READ(5,2)XTAB(I),YTAB(I),XC(I),YC(I)
2  FORMAT(4E10.4)

    XTAB(I) - x coordinate of the I-th point on the input curve (meters).
    YTAB(I) - y coordinate of the I-th point on the input curve (meters).

    XC(I),YC(I) - (meters) Indicate whether the points [XTAB(I), YTAB(I)] and [XTAB(I+1),YTAB(I+1)] are connected by a straight-line segment or an arc with changing radius. If XC(I) = YC(I) = 0, the segment is straight. Otherwise, [XC(I),YC(I)] is assumed to be the center of an arc

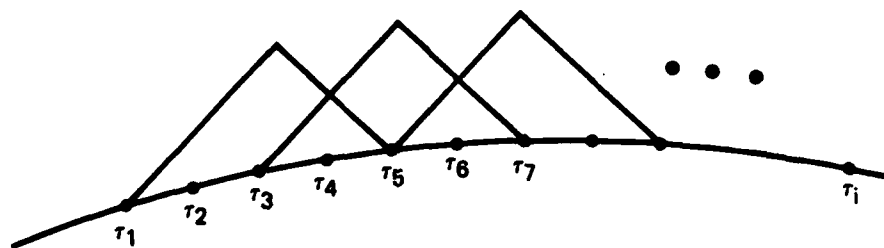
```

with the above end-points, where the radius changes linearly with angle from $[XTAB(I), YTAB(I)]$ to $[XTAB(I+1), YTAB(I+1)]$, subtending the angle of the triangle formed by the three points. Note, if the three points are colinear, the direction of the arc will be clockwise.

For example, consider a cylinder with a cross-section given in Figure 2. The generating curve for this body can be represented with three points (NPTS = 3) as follows:

| | | | |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 3 | 1 | 3 | 0 |
| 4 | 0 | 0 | 0 |

BOTSEG is currently dimensioned to handle 100 points on the input curve and 83 points on the output curve. The NP data points used to represent the BOT generating curve determines the location and number of triangle functions and its derivatives (denoted by arrays T and TP in the codes), used to discretize the unknown currents on the BOT surface. As an example, Figure 2b shows a portion of a BOT generating curve defined by points $\tau_1, \tau_2, \tau_3 \dots \tau_i$ with the triangle functions centered at τ_3, τ_5 , etc. Note the triangle functions span five data points, with adjacent functions overlapping each other.



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Figure 2b. Triangle functions on BOT surface.

2.3 Input Data Description and Formats

A detailed description of the input data required by the five main-line MM/BOT codes is provided below. READ statements and formats are listed in the order in which they appear within the programs, followed by a description of the required data for each of the main-line MM/BOT codes.

2.3.1 Primary Data Set

This data set is read and required by all the programs.

READ(5,1)NMODE

1 FORMAT(I3)

NMODE - Number of non-negative modes to be considered (i.e., there will be $2*NMODE-1$ total modes).

READ(5,2)NPT,NBAND

2 FORMAT(2I3)

NPT - Number of diagonal bands to be used in each $Z_{m,n}^{tt}$, $Z_{m,n}^{zt}$, $Z_{m,n}^{tz}$, and $Z_{m,n}^{zz}$ submatrix. NPT=1 indicates that only the diagonal terms are nonzero in each submatrix, NPT=2 indicates that only diagonal and off-diagonal terms are nonzero, etc. If $NPT \geq (NP-3)/2$, each submatrix is full, where NP is described below.

NBAND - Number of submatrix diagonal bands to be used during the inversion of Z_{BOT} . NBAND=1 indicates that only the diagonal $Z_{m,n}$ submatrices are to be used during inversion. NBAND=2 indicates that diagonal and off-diagonal $Z_{m,n}$ submatrices are to be used, etc. If $NBAND \geq 2*NMODE-1$, the entire Z_{BOT} matrix is inverted.

READ(5,3)NP,MC,BK

3 FORMAT(2I3,E14.7)

NP - Number of points used to describe the BOT generating curve. (NP must be odd.) If the BOT generating curve is closed (i.e., the first and last points coincide), the programs will increase NP by two and add two points to the generating curve (i.e., the YH and XH arrays described below). This new NP should be used in all definitions involving NP (i.e., dimensions, etc.).

MC - Number of terms to be used in the numerical integration of the Green's function [Equation (34) of Volume I].

BK - Wave number for the problem (meters⁻¹).

READ(5,4)(YH(I),I=1,NP)

4 FORMAT(10F8.4)

YH - Array of y coordinates for the generating curve (meters).

READ(5,5)(XH(I),I=1,NP)

5 FORMAT(10F8.4)

 XH - Array of x coordinates for the generating curve (meters).

 READ(5,6)L

6 FORMAT(F8.4)

 L - Half length of the BOT (meters).

2.3.2 Scattering and Radiation Analysis Data Set

 This data set is read by the BOTRA, BOTSCM, and BOTSCB programs. Additional data are required by some of the above programs as specified later.

 READ(5,7)NANG,NT,PHII,THI

7 FORMAT(2I3,2F8.4)

 NANG - Number of fixed radiation or scattering angles, as defined by IPLANE below. NANG radiation or scattering patterns will be calculated.

 NT - Number of varied radiation or scattering angles, as defined by IPLANE below.

 PHII - ϕ angle of incident wave (degrees). Used only in BOTSCB program.

 THI - θ angle of incident wave (degrees). Used only in BOTSCB program.

 READ(5,8)(ANG(I),I=1,NANG)

8 FORMAT(10F8.4)

 ANG - Array of fixed radiation or scattering angles, as defined by IPLANE below.

 READ(5,9)(IPLANE(I),I=1,NANG)

9 FORMAT(10I8)

 IPLANE - Array indicating whether the corresponding element of array ANG is a ϕ or θ angle. IPLANE(I)=1 indicates that ANG(I) is a fixed ϕ angle. In this case, ϕ is fixed at ANG(I) and θ varies between 0° and 180° at NT equally spaced angles. (The only exception is program BOTSCM, where θ varies between 0° and 90° at NT equally spaced angles.) IPLANE(I)=2 indicates that ANG(I) is a fixed θ angle. In this case, θ is fixed at ANG(I) and ϕ varies between 0° and 180° .

2.3.3 Antenna Related Data Set

This data set is read only by the BOTRA program and should be deleted when running the BOTSCB program.

READ(5,10)NSA

10 FORMAT(I3)

NSA - Number of slot antennas on the BOT.

READ(5,11)(IS(K),K=1,NSA)

11 FORMAT(10I8)

IS(K) - Triangle function at which slot antenna K is located (centered).

READ(5,12)(ZO(K),K=1,NSA)

12 FORMAT(10F8.4)

ZO(K) - Starting Z coordinate for antenna K (meters).

READ(5,13)(Z1(K),K=1,NSA)

13 FORMAT(10F8.4)

Z1(K) - Ending Z coordinate for antenna K (meters). (ZO(K) < Z1(K) for all K.)

READ(5,14)(EO(K),K=1,NSA)

14 FORMAT(10F8.4)

EO(K) - Constant excitation across slot antenna K [Equation (59) of Volume I]. (EO(K) is complex.)

READ(5,15)(TEXC(K),K=1,NSA)

15 FORMAT(10F8.4)

TEXC(K) - Indicates t excitation on slot antenna K when TEXC(K) \neq 0. This is the $(U^t)_1$ term in Equation (47) of Volume I.

READ(5,16)(ZEXC(K),K=1,NSA)

16 FORMAT(10F8.4)

ZEXC(K) - Indicates z excitation on slot antenna K when ZEXC(K) \neq 0. This is the $(U^z)_1$ term in Equation (47) of Volume I.

2.3.4 Aperture Analysis Data Set

This data set is read only by the BOTSCB program and should be deleted when running the BOTRA program.

READ(5,17)ZO,Z1,YO,XO,Y1,X1

17 **FORMAT(6F8.4)**

 Z0 - Starting z coordinate for the aperture (meters).

 Z1 - Ending z coordinate for the aperture (meters). If $Z1 \leq Z0$, an aperture is not present, and the remaining parameters in this data set are ignored.

 Y0 - Starting y coordinate for the aperture (meters).

 X0 - Starting x coordinate for the aperture (meters). If the start of the aperture is on generating curve segment I, the point (X0,Y0) should be approximately on the line segment joining (XH(I),YH(I)) and (XH(I+1),YH(I+1)). To be specific, X0 must lie between XH(I) and XH(I+1), and Y0 must lie between YH(I) and YH(I+1).

 Y1 - Ending y coordinate for the aperture (meters).

 X1 - Ending x coordinate for the aperture (meters). If the end of the aperture is on generating curve segment J, the point (X1,Y1) must satisfy the same conditions as (X0,Y0) above with J replacing I. The aperture is assumed to start at (X0,Y0) and extend to (X1,Y1) in the t direction (i.e., in the direction of the generating curve). If the aperture does not cover the peaks of at least two triangle functions, the program will print an error message and stop execution.

2.3.5 Near-Field Analysis Data Set

 This data set is read by the BOTRA and BOTSCB programs.

READ(5,18)NTEST

18 **FORMAT(I3)**

 NTEST - Number of test points at which near-field radiation or scattering is to be calculated. NTEST may be set to zero.

 Repeat the following NTEST times:

READ(5,19)ZTEST,YTEST,XTEST

19 **FORMAT(3F8.4)**

 ZTEST - z coordinate of the test point (meters).

 YTEST - y coordinate of the test point (meters).

 XTEST - x coordinate of the test point (meters).

2.4 Parameter Selection

The choice of most of the parameters in Section 2.3 is specified by the user depending upon the explicit requirements of the problem. For example, NSA is set by the number of slot antennas on the BOT. Similarly, BK is determined by the frequency at which the MM/BOT analysis is carried out. On the other hand, the choice of the parameters NP, MC, and NMODE is based upon the requirements of the MM/BOT theory, as explained below.

The parameter NP specifies the number of coordinate points used to describe the BOT generating curve in the t -direction. These points in turn define the segmentation (strips) of the BOT surface. In general, the separation of the points should not exceed 0.15λ . If the BOT has a rapidly changing surface geometry with sharp curvatures, a higher density of points may be necessary. The resulting number of triangle functions used to expand the surface currents on the BOT is determined by $NM = (NP-3)/2$. Since at least one half of a triangle function should subtend an active aperture antenna in BOTRA and at least two triangle functions must intercept a passive aperture in BOTSCB, the value of NP is specified by these conditions as well as the strip width. As a general principle, the accuracy of the analysis is improved by increasing NP.

The parameter MC is used in the numerical evaluation of the integrated Green's kernel G_{mn} [Equation (26) in Volume I]. A necessary condition for the approximations used in obtaining G_{mn} is that $MC > 8(NMODE-1)$.

The parameter NMODE is set by the length of the BOT. In general, the minimum requirement is that $NMODE \gtrsim 2L/\lambda$, where L is the (axial) half-length of the BOT. This requirement is comparable to the MM/BOR analysis requirement that the maximum circumferential modes used be $n \sim \pi D/\lambda$, where D is the largest diameter of the BOR. As a general observation, the accuracy of the analysis increases and the spatial resolution of the surface currents on the BOT is improved as NMODE is increased. This is particularly true for the edge currents. However, practical computer main memory limitations usually set the upper limit on NMODE.

2.5 Program Dimensions

The MM/BOT programs (Appendix C) are currently set up to handle problems with the following set of parameters. (Some of the arrays are overdimensioned in the listings.)

$$NMODE \leq 4$$

$$NBAND \leq 2*NMODE-1$$

$$NP \leq 19 \text{ (17 for a closed generating curve)}$$

$$MC \leq 50$$

$$NANG \leq 6$$

$$NT \leq 91$$

$$NSA \leq 20$$

$$NAM \leq 12 \text{ (NAM is the number of triangle function peaks subtended by an aperture).}$$

For a different set of input parameters, the minimum dimensions required for each program are listed below. Table 1 contains definitions of the parameters used as the subscripts in the arrays enumerated in the dimension statements.

TABLE 1. DEFINITION OF DIMENSION STATEMENT INDICES

| Parameter | Definition |
|-----------|---|
| LS | NP-3 |
| MC | Input |
| NAM | Number of triangle function peaks subtended by an aperture |
| NANG | Input |
| NM | (NP-3)/2 |
| NMODE | Input |
| NP | Number of points on the generating curve (input). If the curve is closed, use NP+2 in place of NP in all definitions. |
| NSA | Input |
| NT | Input |

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BOTZSS Minimum Dimensions

COMPLEX Z(LS*LS),G((NP-1)*NP/2)

DIMENSION YH(NP),XH(NP),DH(NP-1)

DIMENSION SV(NP-1),CV(NP-1),XS(NP-1),YS(NP-1)

DIMENSION UMN(MC),JK(4)

DIMENSION TP(4*NM),T(4*NM),TZ(4*NM)

BOTINV Minimum Dimensions

DIMENSION YH(NP),XH(NP)

COMPLEX Z(K1),ZI(K2),WORK(K3)

DIMENSION NZ(K4)

COMMON NM,JK(4),LR(K5)

where K1 through K5 depend on NBAND and are defined below.

| NBAND | 1 | <2*NMODE-1 | >2*NMODE-1 |
|-------|--------|--|------------------------|
| K1 | 0 | $LS^2 * \{ (2*NMODE-1) * (2*NBAND-1) - (NBAND-1)*NBAND \}$ | $\{ LS*(2*NMODE-1) \}$ |
| K2 | LS^2 | $LS^2*(2*NMODE-1)$ | LS^2 |
| K3 | 0 | LS | 0 |
| K4 | 0 | 2*NMODE-1 | 0 |
| K5 | LS | LS | $LS*(2*NMODE-1)$ |

BOTRA Minimum Dimensions

DIMENSION IS(NSA),ZO(NSA),Z1(NSA),TEXC(NSA),ZEXC(NSA)

COMPLEX EO(NSA)

COMPLEX VM(LS),VN(LS)

COMPLEX GT(NT),GP(NT)

COMPLEX ESC(3),HSC(3),CUR($LS*(2*NMODE-1)$)

COMPLEX Y($LS*LS$),RT(LS),RP(LS)

COMMON/BODY/DH(NP-1),R(NP-1),SP(NP-1),CP(NP-1),SV(NP-1),CV(NP-1),

BK,L,NP,T(4*NM),TZ(4*NM)

COMMON/TEST/MC,GAMMA,TP(4*NM),XS(NP-1),YS(NP-1)

DIMENSION YH(NP),XH(NP),THR(NT),PHIR(NT)

DIMENSION ANG(NANG),IPLANE(NANG)

Subroutine PLANE dimensions are as follows:

COMMON/BODY/DH(NP-1),R(NP-1),SP(NP-1),CP(NP-1),SV(NP-1),CV(NP-1),

BK,L,NP,T(4*NM),TZ(4*NM)

Subroutine NEARB dimensions are as follows:

COMPLEX G(NP-1),HO(NP-1),H1(NP-1)

COMMON/BODY/DH(NP-1),R(NP-1),SP(NP-1),CP(NP-1),SV(NP-1),CV(NP-1),

BK,L,NP,T(4*NM),TZ(4*NM)

COMMON/TEST/MC,GAMMA,TP(4*NM),XS(NP-1),YS(NP-1)

BOTSCM Minimum Dimensions

COMPLEX STT(NT),SPP(NT),STP(NT),SPT(NT)
COMPLEX YT(LS),YP(LS)
COMPLEX Y(LS*LS),RT(NT*LS),RP(NT*LS)
COMMON/BODY/DH(NP-1),R(NP-1),SP(NP-1),CP(NP-1),SV(NP-1),CV(NP-1),
BK,L,NP,T(4*NM),TZ(4*NM)
DIMENSION YH(NP),XH(NP),THS(NT),PHIS(NT)
DIMENSION ANG(NANG),IPLANE(NANG)

Subroutine PLANE dimensions are given under BOTRA dimensions.

BOTSCB Minimum Dimensions

COMPLEX STT(NT),SPP(NT),STP(NT),SPT(NT)
COMPLEX ESCT(3),HSCT(3),CURT(LS*(2*NMODE-1))
COMPLEX ESCP(3),HSCP(3),CURP(LS*(2*NMODE-1))
COMPLEX Y(LS*LS),RT(LS),RP(LS)
COMMON/BODY/DH(NP-1),R(NP-1),SP(NP-1),CP(NP-1),SV(NP-1),CV(NP-1),
BK,L,NP,T(4*NM),TZ(4*NM)
COMMON/TEST/MC,GAMMA,TP(4*NM),XS(NP-1),YS(NP-1)
COMMON/S/LT(NAM),VLOW(NAM),VHGH(NAM),IT(NAM)
DIMENSION YH(NP),XH(NP),THS(NT),PHIS(NT)
DIMENSION ANG(NANG),IPLANE(NANG)

Subroutine PLANE dimensions are given under BOTRA dimensions.

Subroutine NEARB dimensions are given under BOTRA dimensions.

Subroutine ASYMAC dimensions are as follows:

COMPLEX YA(NAM*NAM),CAT(2*NAM),CAP(2*NAM),EVT(2*NAM),EVP(2*NAM)
DIMENSION FPP(3,NAM)FPPZ(3,NAM),LR(2*NAM)
COMMON/S/LT(NAM),VLOW(NAM),VHGH(NAM),IT(NAM)

Subroutine APPAR dimensions are as follows:

COMMON/S/LT(NAM),VLOW(NAM),VHGH(NAM),IT(NAM)

2.6 Sample Problems

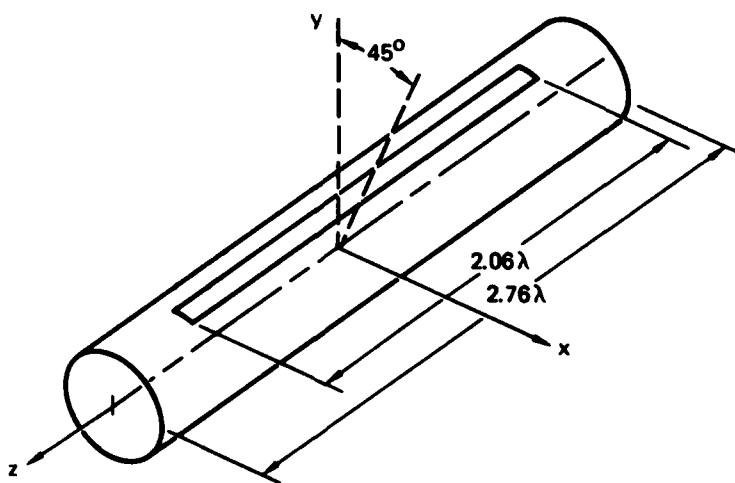
In this section, four sample problems are considered to illustrate the use of the MM/BOT algorithm. Sample problem 1 exercises all the main-line programs given in Figure 1. The inputs, outputs, and selected intermediate results are reproduced here to provide a check case for the proper function-

ing of the codes. Problem 2 demonstrates the radiation analysis for aperture antennas embedded in an asymmetric BOT (i.e., wing section). Problem 3 considers the scattering from a square cylinder of finite length. Finally, problem 4 demonstrates the use of the codes to compute the aperture-coupled electric and magnetic fields inside a BOT, approximating a fuselage equipment compartment when subject to electromagnetic illumination.

2.6.1 Problem 1a

Consider a right-circular cylinder of 2.76λ length and 0.216λ radius, with an embedded ϕ -polarized aperture antenna at $\phi = 0^\circ$. The aperture is fed uniformly, subtends a 45° opening, and is 2.06λ long in the axial direction (see Figure 3a).

- Calculate the power gain patterns in the horizontal ($\phi = 0, 180^\circ$) plane and the roll ($\theta = \pm 90^\circ$) planes in the θ and ϕ polarizations.
- Compute the currents on the cylinder surface.
- Compute the electric and magnetic field components (near fields) at test points on a line bisecting the aperture, i.e., at $X_{TEST} = 14.256, 19.44, 71.28, 150, \text{ and } 300 \text{ m}$ where the corresponding $Y_{TEST} = Z_{TEST} = 0.0$.



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Figure 3a. Slotted cylinder for problem 1.

Solution - The problem was solved by running the programs BOTSEG, BOTZSS, BOTINV, and BOTRA in sequence. The calculations were carried out at 10 MHz ($\lambda = 30$ m). The cylinder was represented by NP = 17 points around the circumference.

Execution of BOTSEG is shown in Figure 3b, together with the data file for the coordinates of the problem and a plot of the NP data points and triangle functions for the cylinder cross section. (Note Figure 3b was generated in a time-share mode. The question marks at the beginning of each line are prompt signs used in the time-share mode.) The generated file was used as the basic input file for the programs BOTZSS, BOTINV, and BOTRA. Four modes were used in the calculations, i.e., NMODE = 4. Partial listings of the inputs and outputs from these programs are shown in the subsequent figures. Specifically, the input data for execution of the programs are given in Figure 4. For reference, the variable of the data set are labeled with the applicable format statements in parenthesis. Note the aperture coincided with the fourth triangle function (IS = 4) and only one triangle function was used to span the aperture (NSA = 1). If a non-uniform aperture excitation is desired, then more triangle functions should be used to span the aperture each with a different E_0 . Partial outputs from BOTZSS, BOTINV, and BOTRA are shown in Figures 5, 6, and 7, respectively. The radiation power gain for the slotted cylinder for the horizontal and roll planes normalized to an isotropic radiator is summarized in Figure 7b. (The comparison of these results with the MM/BOR analysis is given in Figure 10 of Volume I.) Partial output of the currents on the cylinder is plotted in Figure 7c. The electric and magnetic fields computed in the near-field analysis are listed in Figure 7d. (For further discussion of these results, see Section 8 of Volume I.)

The foregoing calculations were carried out at 10 MHz. If the dimensions of the body (BOT) and the antenna are given initially in terms of wavelength, any convenient frequency can be chosen in the setup procedure for carrying out the computations. If the data are to be compared with range measurements at a given frequency, for ease of data interpretation, the calculations are also done at that frequency.

RNH BOTSEG

? 3 17

? 0.0 0.0 6.48 0.0 } (2I3)
 ? 12.96 0.0 6.48 0.0 } (4E10.4)
 ? 0.0 0.0

PERIMETER = 40.7150

NP = 17

YH

0.0000 2.4798 4.5821 5.9867 6.4800 5.9867 4.5821 2.4798 0.0000 -2.4798
 -4.5821 -5.9867 -6.4800 -5.9867 -4.5821 -2.4798 0.0000

XH

0.0000 .4933 1.8979 4.0002 6.4800 8.9598 11.0621 12.4667 12.9600 12.4667
 11.0621 8.9598 6.4800 4.0002 1.8979 .4933 0.0000

BODY COORDINATES + INDICATES TRIANGLE PEAK

| | | | | | | | |
|---------|------|---|---|---|---|-----|---|
| 6.4800 | 1 | | | + | | | I |
| 6.0480 | 1 | | ♦ | 2 | | ♦ | I |
| 5.6160 | 1 | | | | | | I |
| 5.1840 | 1 | | | | | | I |
| 4.7520 | 1 | | + | | | + | I |
| 4.3200 | 1 | | 1 | | | 3 | I |
| 3.8880 | 1 | | | | | | I |
| 3.4560 | 1 | | | | | | I |
| 3.0240 | 1 | | | | | | I |
| 2.5920 | 1 | ♦ | | | | | I |
| 2.1600 | 1 | | | | | | I |
| 1.7280 | 1 | | | | | | I |
| 1.2960 | 1 | | | | | | I |
| .8640 | 1 | | | | | | I |
| .4320 | 1 | | | | | | I |
| .0000 | 1+ 8 | | | | | | I |
| -.4320 | 1 | | | | | 4 + | I |
| -.8640 | 1 | | | | | | I |
| -1.2960 | 1 | | | | | | I |
| -1.7280 | 1 | | | | | | I |
| -2.1600 | 1 | | | | | | I |
| -2.5920 | 1 | ♦ | | | | | I |
| -3.0240 | 1 | | | | | | I |
| -3.4560 | 1 | | | | | | I |
| -3.8880 | 1 | | | | | | I |
| -4.3200 | 1 | | | | | | I |
| -4.7520 | 1 | | + | | | 5 + | I |
| -5.1840 | 1 | | | | | | I |
| -5.6160 | 1 | | | | | | I |
| -6.0480 | 1 | | ♦ | | 6 | | I |
| -6.4800 | 1 | | | + | | | I |

YH / XH 1 1 1 1 1 1

STOP 0.0000 2.5920 5.1840 7.7760 10.3680 12.9600

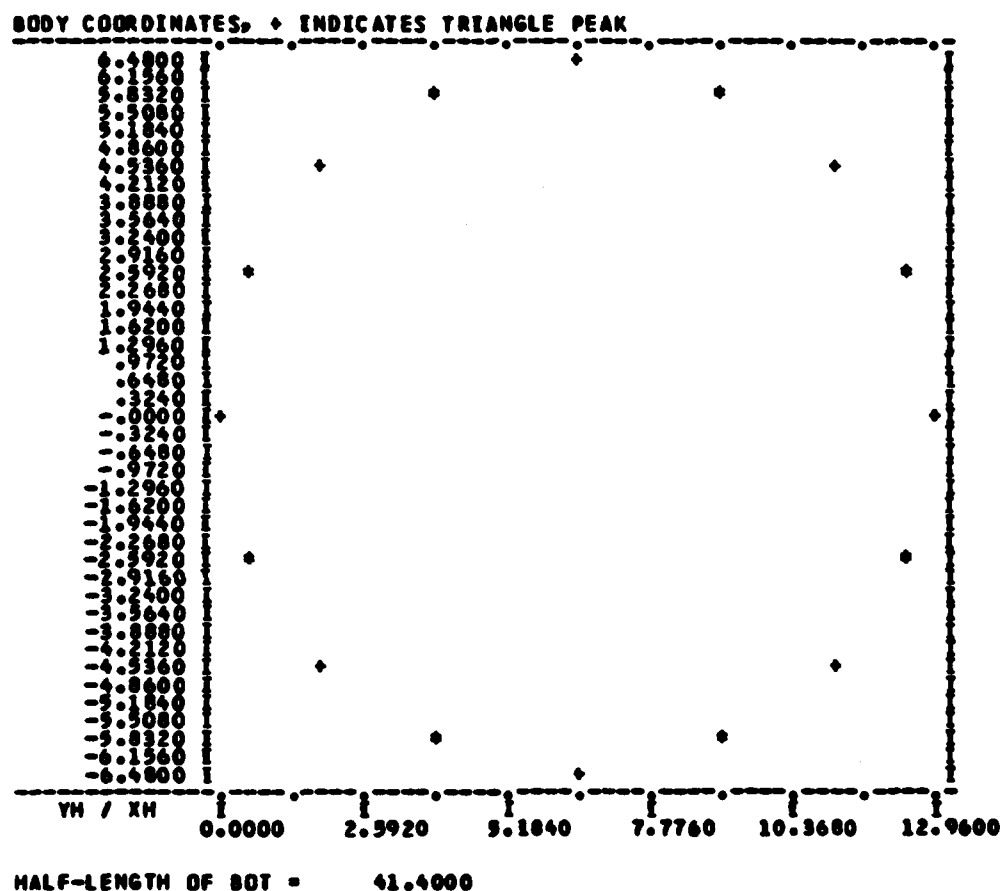
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Figure 3b. Execution of BOTSEG for problem 1, with triangle functions numbered on the plot.


```

NPT  NPARAM  NMODE  NP  NC  .2094397E+00
20      14      4      17   36
YH
0.0000  2.4798  4.9596  7.4394  9.9192  12.3990  14.8788  17.3586  19.8384  22.3182
-4.9596 -9.9192 -14.8788 -19.8384 -24.7980 -29.7576 -34.7172 -39.6768 -44.6364 -49.5960
XH
0.0000  .4933  1.8979  4.0002  6.4800  8.9598  11.0621  12.4667  12.9600  12.4667
11.0621  8.9598  6.4800  4.0002  1.8979  .4933  0.0000

```



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Figure 5a. Partial output of BOTZSS for problem 1a.

[illegible]

Figure 5b. Partial output of BOTZSS - impedance matrices for problem 1a.

20270-0031-20

| | NP 17 | NMODE 4 | NBAND 14 | | | | | | | | |
|----|----------|------------|-------------|---------|---------|---------|---------|---------|---------|---------|--|
| YH | 0.0000 | 2.4798 | 4.5821 | 3.9867 | 6.4800 | 3.9867 | 4.5821 | 2.4798 | 0.0000 | -2.4798 | |
| | -4.5821 | -3.9867 | -6.4800 | -3.9867 | -4.5821 | -2.4798 | 0.0000 | | | | |
| XH | 0.0000 | 8.4933 | 1.3979 | 4.0002 | 6.4800 | 8.4933 | 11.0621 | 12.4667 | 12.9600 | 12.4667 | |
| | 11.0621 | 8.4933 | 6.4800 | 4.0002 | 1.3979 | 8.4933 | 0.0000 | | | | |

THE MINIMUM BOTINV ARRAY DIMENSIONS FOR THIS
PROBLEM ARE AS FOLLOWS:

| Z | ZI | WORK | NZ | LR |
|-------|-----|------|----|-----|
| 12544 | 256 | 0 | 0 | 112 |

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Figure 6a. Partial output of BOTINV for problem 1a.

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|-------|-------|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|
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| V2 | | | | | | | | | | | | | | | | | | | | |
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| V3 | | | | | | | | | | | | | | | | | | | | |
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| V4 | | | | | | | | | | | | | | | | | | | | |
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NPT 20 NBAND 14 NMODE 4 NP 17 MC 50 BK .2094397E+00
 YH 0.0000 -3.4798 2.5821 3.9867 6.4800 3.9867 2.4798 0.0000 -2.4798
 -4.9821 -3.9867 -2.4800 -3.9867 -4.5821 -3.9867 0.0000
 XH 0.0000 .4933 1.8979 4.0002 6.4800 6.9598 11.0621 12.4667 12.9600 12.4667
 11.0621 6.9598 6.4800 4.0002 1.8979 .4933 0.0000

HALF-LENGTH OF BOT = 41.4000

NUMBER OF FIXED ANGLES = 4

NUMBER OF ANGLES PER FIXED ANGLE = 46

FIXED ANGLE CODE(PHI FIXED = 1, THETA FIXED = 2)

0.0
 180.0
 90.0
 -90.0

NUMBER OF SLOT ANTENNAS = 1

| ANTENNA NO. | IS | Z0 | Z1 | E0 | TEXC | ZEXC |
|-------------|----|----------|---------|--------|--------|--------|
| 1 | 4 | -31.0500 | 31.0500 | 1.0000 | 1.0000 | 0.0000 |

Figure 7a. Partial output of BOTRA for problem 1a.

Power radiation patterns
Horizontal plane ($\phi = 0^\circ$)

TOTAL POWER(DB) = -2.21

| PHI | THETA | POWER(DB) | |
|------|-------|-----------|--------|
| | | ° | ° |
| 0.0 | 0.0 | -205.70 | -76.39 |
| 00.0 | 4.0 | -206.01 | -76.04 |
| 00.0 | 8.0 | -206.05 | -75.48 |
| 00.0 | 12.0 | -204.89 | -74.83 |
| 00.0 | 16.0 | -202.30 | -73.36 |
| 00.0 | 20.0 | -199.24 | -70.34 |
| 00.0 | 24.0 | -196.41 | -66.47 |
| 00.0 | 28.0 | -194.07 | -62.73 |
| 00.0 | 32.0 | -192.29 | -59.47 |
| 00.0 | 36.0 | -191.12 | -56.79 |
| 00.0 | 40.0 | -190.63 | -54.74 |
| 00.0 | 44.0 | -190.96 | -53.39 |
| 00.0 | 48.0 | -192.37 | -52.89 |
| 00.0 | 52.0 | -195.38 | -53.66 |
| 00.0 | 56.0 | -201.22 | -56.56 |
| 00.0 | 60.0 | -202.70 | -60.55 |
| 00.0 | 64.0 | -196.45 | -57.89 |
| 00.0 | 68.0 | -193.21 | -49.37 |
| 00.0 | 72.0 | -191.87 | -44.69 |
| 00.0 | 76.0 | -191.93 | -41.58 |
| 00.0 | 80.0 | -193.39 | -39.49 |
| 00.0 | 84.0 | -196.99 | -38.19 |
| 00.0 | 88.0 | -205.98 | -37.55 |
| 00.0 | 92.0 | -205.98 | -37.55 |
| 00.0 | 96.0 | -196.99 | -38.19 |
| 00.0 | 100.0 | -193.39 | -39.49 |
| 00.0 | 104.0 | -191.93 | -41.58 |
| 00.0 | 108.0 | -191.87 | -44.69 |
| 00.0 | 112.0 | -193.21 | -49.37 |
| 00.0 | 116.0 | -196.45 | -57.89 |
| 00.0 | 120.0 | -202.70 | -60.55 |
| 00.0 | 124.0 | -201.22 | -56.56 |
| 00.0 | 128.0 | -195.38 | -53.66 |
| 00.0 | 132.0 | -192.37 | -52.89 |
| 00.0 | 136.0 | -190.96 | -53.39 |
| 00.0 | 140.0 | -190.63 | -54.74 |
| 00.0 | 144.0 | -191.12 | -56.79 |
| 00.0 | 148.0 | -192.29 | -59.47 |
| 00.0 | 152.0 | -194.07 | -62.73 |
| 00.0 | 156.0 | -196.41 | -66.47 |
| 00.0 | 160.0 | -199.24 | -70.34 |
| 00.0 | 164.0 | -202.30 | -73.36 |
| 00.0 | 168.0 | -204.89 | -74.83 |
| 00.0 | 172.0 | -206.05 | -75.48 |
| 00.0 | 176.0 | -206.01 | -76.04 |
| 00.0 | 180.0 | -205.70 | -76.39 |

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Figure 7b. Partial output of BOTRA for problem 1a.

| PHI | THETA | POWER(DB) | |
|-------|-------|-----------|--------|
| | | ° | ° |
| 180.0 | 0.0 | -203.64 | -76.39 |
| 180.0 | 4.0 | -203.44 | -75.95 |
| 180.0 | 8.0 | -203.24 | -74.58 |
| 180.0 | 12.0 | -203.01 | -72.76 |
| 180.0 | 16.0 | -202.73 | -70.91 |
| 180.0 | 20.0 | -202.42 | -69.11 |
| 180.0 | 24.0 | -202.13 | -67.27 |
| 180.0 | 28.0 | -202.00 | -65.30 |
| 180.0 | 32.0 | -202.17 | -63.25 |
| 180.0 | 36.0 | -202.83 | -61.31 |
| 180.0 | 40.0 | -204.08 | -59.70 |
| 180.0 | 44.0 | -205.60 | -58.63 |
| 180.0 | 48.0 | -205.85 | -58.36 |
| 180.0 | 52.0 | -204.27 | -59.28 |
| 180.0 | 56.0 | -202.80 | -62.54 |
| 180.0 | 60.0 | -202.71 | -74.42 |
| 180.0 | 64.0 | -204.79 | -62.41 |
| 180.0 | 68.0 | -211.41 | -54.57 |
| 180.0 | 72.0 | -219.13 | -50.02 |
| 180.0 | 76.0 | -207.31 | -46.95 |
| 180.0 | 80.0 | -204.81 | -44.85 |
| 180.0 | 84.0 | -206.36 | -43.52 |
| 180.0 | 88.0 | -214.59 | -42.68 |
| 180.0 | 92.0 | -214.59 | -42.88 |
| 180.0 | 96.0 | -206.36 | -43.52 |
| 180.0 | 100.0 | -204.81 | -44.85 |
| 180.0 | 104.0 | -207.31 | -46.95 |
| 180.0 | 108.0 | -219.13 | -50.02 |
| 180.0 | 112.0 | -211.41 | -54.57 |
| 180.0 | 116.0 | -204.79 | -62.41 |
| 180.0 | 120.0 | -202.71 | -74.42 |
| 180.0 | 124.0 | -202.80 | -62.54 |
| 180.0 | 128.0 | -204.27 | -59.28 |
| 180.0 | 132.0 | -205.85 | -58.36 |
| 180.0 | 136.0 | -205.60 | -58.63 |
| 180.0 | 140.0 | -204.08 | -59.70 |
| 180.0 | 144.0 | -202.83 | -61.31 |
| 180.0 | 148.0 | -202.17 | -63.25 |
| 180.0 | 152.0 | -202.00 | -65.30 |
| 180.0 | 156.0 | -202.13 | -67.27 |
| 180.0 | 160.0 | -202.42 | -69.11 |
| 180.0 | 164.0 | -202.73 | -70.91 |
| 180.0 | 168.0 | -203.01 | -72.76 |
| 180.0 | 172.0 | -203.24 | -74.58 |
| 180.0 | 176.0 | -203.44 | -75.95 |
| 180.0 | 180.0 | -203.64 | -76.39 |

Horizontal plane
($\phi = 180^\circ$)

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Figure 7b. Partial output of BOTRA for problem 1a. (continued)

| PHI | THETA | POWER (DB) | |
|-------|-------|------------|--------|
| | | 0 | 90 |
| 0.0 | 90.0 | -315.69 | -37.48 |
| 4.0 | 90.0 | -204.13 | -37.48 |
| 8.0 | 90.0 | -198.12 | -37.49 |
| 12.0 | 90.0 | -194.62 | -37.50 |
| 16.0 | 90.0 | -192.15 | -37.52 |
| 20.0 | 90.0 | -190.25 | -37.54 |
| 24.0 | 90.0 | -188.71 | -37.56 |
| 28.0 | 90.0 | -187.43 | -37.59 |
| 32.0 | 90.0 | -186.34 | -37.62 |
| 36.0 | 90.0 | -185.40 | -37.65 |
| 40.0 | 90.0 | -184.58 | -37.69 |
| 44.0 | 90.0 | -183.86 | -37.73 |
| 48.0 | 90.0 | -183.22 | -37.77 |
| 52.0 | 90.0 | -182.66 | -37.82 |
| 56.0 | 90.0 | -182.17 | -37.88 |
| 60.0 | 90.0 | -181.74 | -37.96 |
| 64.0 | 90.0 | -181.37 | -38.05 |
| 68.0 | 90.0 | -181.05 | -38.15 |
| 72.0 | 90.0 | -180.78 | -38.30 |
| 76.0 | 90.0 | -180.56 | -38.47 |
| 80.0 | 90.0 | -180.38 | -38.68 |
| 84.0 | 90.0 | -180.23 | -38.94 |
| 88.0 | 90.0 | -180.15 | -39.24 |
| 92.0 | 90.0 | -180.11 | -39.60 |
| 96.0 | 90.0 | -180.10 | -40.02 |
| 100.0 | 90.0 | -180.14 | -40.50 |
| 104.0 | 90.0 | -180.22 | -41.05 |
| 108.0 | 90.0 | -180.35 | -41.68 |
| 112.0 | 90.0 | -180.52 | -42.37 |
| 116.0 | 90.0 | -180.75 | -43.13 |
| 120.0 | 90.0 | -181.03 | -43.92 |
| 124.0 | 90.0 | -181.36 | -44.72 |
| 128.0 | 90.0 | -181.76 | -45.44 |
| 132.0 | 90.0 | -182.23 | -46.01 |
| 136.0 | 90.0 | -182.78 | -46.33 |
| 140.0 | 90.0 | -183.42 | -46.36 |
| 144.0 | 90.0 | -184.17 | -46.11 |
| 148.0 | 90.0 | -185.04 | -45.66 |
| 152.0 | 90.0 | -186.07 | -45.13 |
| 156.0 | 90.0 | -187.29 | -44.57 |
| 160.0 | 90.0 | -188.78 | -44.06 |
| 164.0 | 90.0 | -190.63 | -43.62 |
| 168.0 | 90.0 | -193.07 | -43.26 |
| 172.0 | 90.0 | -196.55 | -43.00 |
| 176.0 | 90.0 | -202.54 | -42.83 |
| 180.0 | 90.0 | -317.80 | -42.80 |

Roll plane
($\theta = 90^\circ$)

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Figure 7b. Partial output of BOTRA for problem 1a. (continued)

| PHI | THETA | POWER(DB) | |
|-------|-------|-----------|--------|
| | | ● | ■ |
| 0.0 | -90.0 | -318.94 | -42.80 |
| 4.0 | -90.0 | -202.54 | -42.85 |
| 8.0 | -90.0 | -196.53 | -43.00 |
| 12.0 | -90.0 | -193.07 | -43.26 |
| 16.0 | -90.0 | -190.63 | -43.62 |
| 20.0 | -90.0 | -188.78 | -44.06 |
| 24.0 | -90.0 | -187.29 | -44.57 |
| 28.0 | -90.0 | -186.07 | -45.13 |
| 32.0 | -90.0 | -185.04 | -45.66 |
| 36.0 | -90.0 | -184.17 | -46.11 |
| 40.0 | -90.0 | -183.42 | -46.36 |
| 44.0 | -90.0 | -182.78 | -46.33 |
| 48.0 | -90.0 | -182.23 | -46.01 |
| 52.0 | -90.0 | -181.76 | -45.44 |
| 56.0 | -90.0 | -181.36 | -44.72 |
| 60.0 | -90.0 | -181.03 | -43.92 |
| 64.0 | -90.0 | -180.75 | -43.13 |
| 68.0 | -90.0 | -180.52 | -42.37 |
| 72.0 | -90.0 | -180.35 | -41.68 |
| 76.0 | -90.0 | -180.22 | -41.05 |
| 80.0 | -90.0 | -180.14 | -40.50 |
| 84.0 | -90.0 | -180.10 | -40.02 |
| 88.0 | -90.0 | -180.11 | -39.60 |
| 92.0 | -90.0 | -180.15 | -39.24 |
| 96.0 | -90.0 | -180.23 | -38.94 |
| 100.0 | -90.0 | -180.38 | -38.68 |
| 104.0 | -90.0 | -180.56 | -38.47 |
| 108.0 | -90.0 | -180.78 | -38.30 |
| 112.0 | -90.0 | -181.03 | -38.16 |
| 116.0 | -90.0 | -181.37 | -38.05 |
| 120.0 | -90.0 | -181.74 | -37.96 |
| 124.0 | -90.0 | -182.17 | -37.88 |
| 128.0 | -90.0 | -182.66 | -37.82 |
| 132.0 | -90.0 | -183.22 | -37.77 |
| 136.0 | -90.0 | -183.86 | -37.73 |
| 140.0 | -90.0 | -184.58 | -37.69 |
| 144.0 | -90.0 | -185.40 | -37.65 |
| 148.0 | -90.0 | -186.34 | -37.62 |
| 152.0 | -90.0 | -187.43 | -37.59 |
| 156.0 | -90.0 | -188.71 | -37.56 |
| 160.0 | -90.0 | -190.25 | -37.54 |
| 164.0 | -90.0 | -192.15 | -37.52 |
| 168.0 | -90.0 | -194.62 | -37.50 |
| 172.0 | -90.0 | -198.12 | -37.49 |
| 176.0 | -90.0 | -204.13 | -37.48 |
| 180.0 | -90.0 | -312.13 | -37.48 |

Roll plane
($\theta = -90^\circ$)

GP78-0481-103

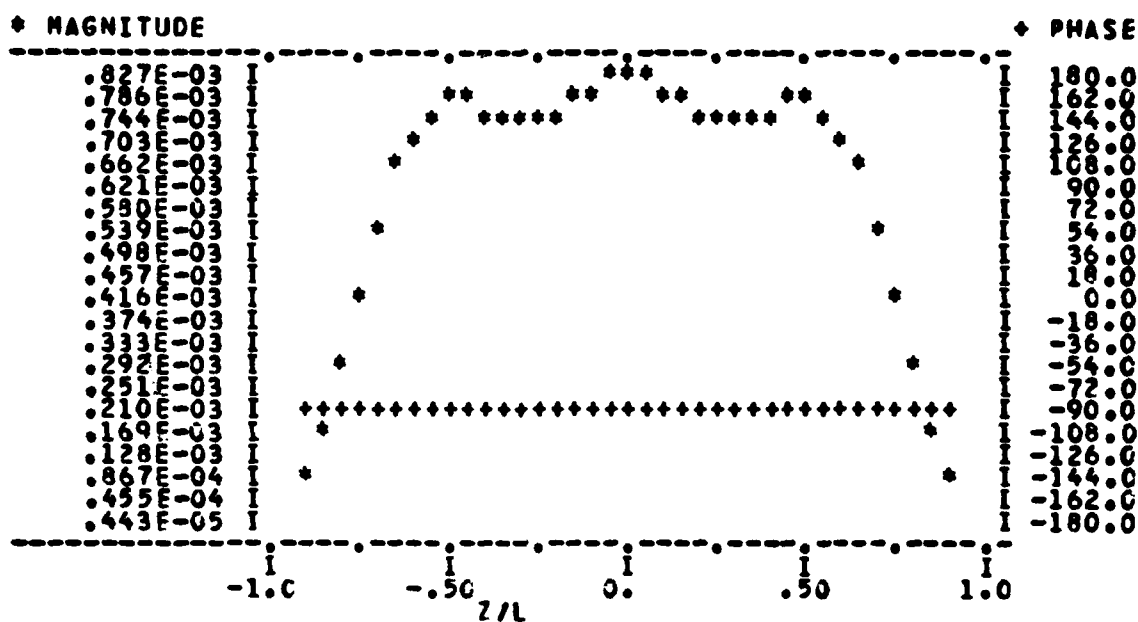
Figure 7b. Partial output of BOTRA for problem 1a. (concluded)

0270-0151-36

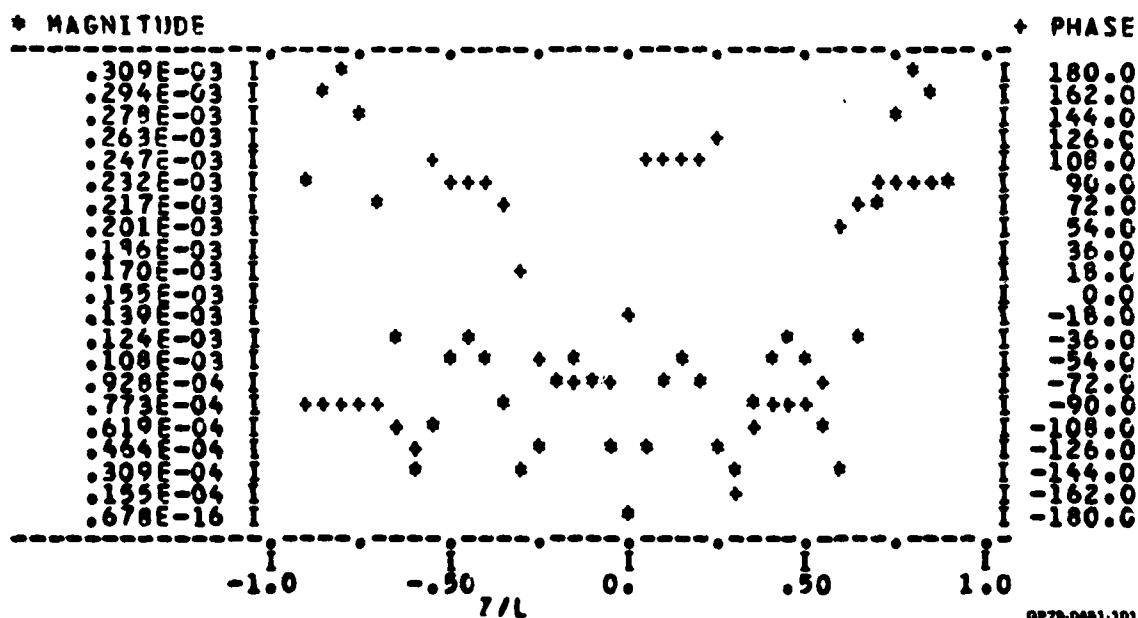
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Plot of currents along BOT

T-DIRECTED CURRENTS ON TRIANGLE FUNCTION 1



Z-DIRECTED CURRENTS ON TRIANGLE FUNCTION 1



GP79-0481-101

Figure 7c. Partial output of BOTRA for problem 1a. (concluded)

.EAP FIELD ANALYSIS

| ZTEST | YTEST | XTEST |
|--------|--------|----------|
| 0.0000 | 0.0000 | 14.2560 |
| 0.0000 | 0.0000 | 19.4400 |
| 0.0000 | 0.0000 | 71.2800 |
| 0.0000 | 0.0000 | 150.0000 |
| 0.0000 | 0.0000 | 300.0000 |

| E-FIELD | | | H-FIELD | | |
|------------------|-----------|-----------|------------------|-----------|-----------|
| FIELD COMPONENTS | | | FIELD COMPONENTS | | |
| RADIAL | THETA | PHI | RADIAL | THETA | PHI |
| .1033E-06 | .3601E-14 | .1093E+01 | .3002E-16 | .1453E-02 | .3123E-17 |
| .4552E-07 | .1958E-14 | .3478E+00 | .2440E-16 | .8615E-03 | .2117E-17 |
| .4246E-08 | .5100E-15 | .1278E+00 | .6287E-17 | .3254E-03 | .9705E-18 |
| .9580E-09 | .1533E-15 | .6319E-01 | .1604E-17 | .1660E-03 | .2613E-18 |
| .3313E-09 | .3328E-16 | .3086E-01 | .2145E-18 | .8170E-04 | .9180E-19 |

08770-04081-37

Figure 7d. Partial output of BOTRA - near fields for problem 1a.

2.6.2 Problem 1b

Compute the monostatic (backscatter) cross sections at 10 MHz for the following received and transmitted polarizations $\theta\theta$, $\phi\phi$, $\phi\theta$, and $\theta\phi$ in the horizontal ($\phi = 0$) and roll ($\theta = 90$) planes for the cylinder configuration used in problem 1a. For this part of the problem, assume that there is no aperture on the cylinder. Compute the cross sections at 46(NT) equispaced angles.

Solution - Since the basic body configuration was not altered, the results from BOTZSS and hence BOTINV in problem 1a are used. The cross sections were obtained from BOTSCM. Figure 8 depicts the input data to execute BOTSCM. Partial listings of the output from BOTSCM including the scattering cross sections are given in Figure 9.

| | | | | | | | | | | | | | | | | | | | |
|----|------|--------------|---------|---------|---------|---------|---------|---------|---------|---------|--|--|--|--|--|--|--|--|--|
| 20 | 14 | | | | | | | | | | | | | | | | | | |
| 17 | 30 | .2094397E+00 | | | | | | | | | | | | | | | | | |
| 0 | 0000 | -2.4798 | 4.5821 | -5.9867 | -6.4800 | -5.9867 | 4.5821 | 2.4798 | -0.0000 | -2.4798 | | | | | | | | | |
| -4 | 5821 | -5.9867 | -6.4800 | -5.9867 | -6.4800 | -5.9867 | -6.4800 | 0.0000 | | | | | | | | | | | |
| 0 | 0000 | 8.4933 | 1.8979 | 4.0002 | 6.4800 | 8.4933 | 11.9821 | 12.4667 | 12.9600 | 12.4667 | | | | | | | | | |
| 11 | 0621 | 8.4933 | 6.4800 | 4.0002 | 1.8979 | .4933 | 0.0000 | | | | | | | | | | | | |
| 4 | 1 | | | | | | | | | | | | | | | | | | |
| 2 | 46 | | | | | | | | | | | | | | | | | | |
| | 0.0 | | | | | | | | | | | | | | | | | | |
| | | 90.0 | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |

Primary
BOT
data set

Scattering angles

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Figure 8. Input data for execution of BOTSCM for problem 1b.

| | NPT 20 | NBAND 14 | NMODE 4 | NP 17 | MC 50 | BK .2094397E+00 | | | | |
|---------------------------------------|---|-------------|------------|----------|----------|--------------------|---------|---------|---------|---------|
| YH | 0.0000 | 2.4798 | 4.5821 | 5.9867 | 6.4800 | 5.9867 | 4.5821 | 2.4798 | 0.0000 | -2.4798 |
| | -4.5821 | -5.9867 | -6.4800 | -5.9867 | -4.5821 | -2.4798 | 0.0000 | | | |
| XH | 0.0000 | .4933 | 1.8979 | 4.0002 | 6.4800 | 8.9598 | 11.0621 | 12.4667 | 12.9600 | 12.4667 |
| | 11.0621 | 8.9598 | 6.4800 | 4.0002 | 1.8979 | .4933 | 0.0000 | | | |
| HALF-LENGTH OF BOT = 41.4000 | | | | | | | | | | |
| NUMBER OF FIXED ANGLES = 2 | | | | | | | | | | |
| NUMBER OF ANGLES PER FIXED ANGLE = 46 | | | | | | | | | | |
| FIXED ANGLE | CODE(PHI FIXED = 1, THETA FIXED = 2) | | | | | | | | | |
| 0.0 | 1 | | | | | | | | | |
| 90.0 | 2 | | | | | | | | | |
| M= -3 N= -3 | | | | | | | | | | |
| Y | .9073311E-04 -.4701087E-03 .6824476E-04 -.5931252E-03 | | | | | | | | | |
| M= -2 N= -3 | | | | | | | | | | |
| Y | -.7578904E-04 .1196460E-04 -.5825230E-04 .2733491E-04 | | | | | | | | | |
| M= -1 N= -3 | | | | | | | | | | |
| Y | .8818303E-04 .1279038E-04 .6279109E-04 -.2656702E-04 | | | | | | | | | |

GP75-0451-20

Figure 9a. Partial output of BOTSCM for problem 1b.

Horizontal plane ($\phi = 0^\circ$)

[illegible]

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Monostatic scattering cross section
Roll plane ($\theta = 90^\circ$)

| PHI | THETA | MONO-STATIC RCS (DB) | | | |
|-------|-------|----------------------|------|---------|---------|
| | | 00 | 00 | 00 | 00 |
| 0.0 | 90.0 | 10.77 | 7.77 | -271.84 | -271.49 |
| 4.0 | 90.0 | 10.77 | 7.77 | -201.12 | -201.12 |
| 8.0 | 90.0 | 10.78 | 7.78 | -196.54 | -196.54 |
| 12.0 | 90.0 | 10.78 | 7.78 | -195.66 | -195.66 |
| 16.0 | 90.0 | 10.79 | 7.79 | -197.69 | -197.69 |
| 20.0 | 90.0 | 10.79 | 7.79 | -204.98 | -204.98 |
| 24.0 | 90.0 | 10.79 | 7.79 | -209.12 | -209.12 |
| 28.0 | 90.0 | 10.79 | 7.79 | -198.73 | -198.73 |
| 32.0 | 90.0 | 10.78 | 7.78 | -195.84 | -195.84 |
| 36.0 | 90.0 | 10.78 | 7.78 | -196.02 | -196.02 |
| 40.0 | 90.0 | 10.78 | 7.77 | -199.42 | -199.42 |
| 44.0 | 90.0 | 10.77 | 7.77 | -212.71 | -212.71 |
| 48.0 | 90.0 | 10.77 | 7.77 | -203.40 | -203.40 |
| 52.0 | 90.0 | 10.78 | 7.77 | -197.21 | -197.21 |
| 56.0 | 90.0 | 10.78 | 7.78 | -195.58 | -195.58 |
| 60.0 | 90.0 | 10.79 | 7.79 | -196.82 | -196.82 |
| 64.0 | 90.0 | 10.79 | 7.79 | -202.11 | -202.11 |
| 68.0 | 90.0 | 10.79 | 7.79 | -219.06 | -219.06 |
| 72.0 | 90.0 | 10.79 | 7.79 | -200.23 | -200.23 |
| 76.0 | 90.0 | 10.79 | 7.78 | -196.27 | -196.27 |
| 80.0 | 90.0 | 10.78 | 7.78 | -195.74 | -195.74 |
| 84.0 | 90.0 | 10.78 | 7.77 | -198.19 | -198.19 |
| 88.0 | 90.0 | 10.77 | 7.77 | -206.80 | -206.80 |
| 92.0 | 90.0 | 10.77 | 7.77 | -206.80 | -206.80 |
| 96.0 | 90.0 | 10.78 | 7.77 | -198.19 | -198.19 |
| 100.0 | 90.0 | 10.78 | 7.78 | -195.74 | -195.74 |
| 104.0 | 90.0 | 10.79 | 7.78 | -196.27 | -196.27 |
| 108.0 | 90.0 | 10.79 | 7.79 | -200.23 | -200.23 |
| 112.0 | 90.0 | 10.79 | 7.79 | -219.06 | -219.06 |
| 116.0 | 90.0 | 10.79 | 7.79 | -202.11 | -202.11 |
| 120.0 | 90.0 | 10.79 | 7.79 | -196.82 | -196.82 |
| 124.0 | 90.0 | 10.78 | 7.78 | -195.58 | -195.58 |
| 128.0 | 90.0 | 10.78 | 7.77 | -197.21 | -197.21 |
| 132.0 | 90.0 | 10.77 | 7.77 | -203.40 | -203.40 |
| 136.0 | 90.0 | 10.77 | 7.77 | -212.71 | -212.71 |
| 140.0 | 90.0 | 10.78 | 7.77 | -199.42 | -199.42 |
| 144.0 | 90.0 | 10.78 | 7.78 | -196.02 | -196.02 |
| 148.0 | 90.0 | 10.78 | 7.78 | -195.84 | -195.84 |
| 152.0 | 90.0 | 10.79 | 7.79 | -198.73 | -198.73 |
| 156.0 | 90.0 | 10.79 | 7.79 | -209.12 | -209.12 |
| 160.0 | 90.0 | 10.79 | 7.79 | -204.98 | -204.98 |
| 164.0 | 90.0 | 10.79 | 7.79 | -197.69 | -197.69 |
| 168.0 | 90.0 | 10.78 | 7.78 | -195.66 | -195.66 |
| 172.0 | 90.0 | 10.78 | 7.78 | -196.54 | -196.54 |
| 176.0 | 90.0 | 10.77 | 7.77 | -201.12 | -201.12 |
| 180.0 | 90.0 | 10.77 | 7.77 | -268.85 | -268.85 |

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Figure 9c. Partial output of BOTSCM for problem 1b.

2.6.3 Problem 1c

Consider the cylinder in problem 1a with a passive aperture subtending an angle of 45° and extending from $-27.9 \leq Z \leq 27.9$ m along the length of the BOT. Let the edges of the aperture parallel to the z-axis be defined by the coordinates $Y0 = 4.5822$, $X0 = 11.062$, and $Y1 = -0.001$, $X1 = 12.95$. (Let $NP = 17$ and $NMODE = 4$.)

- a) Calculate the bistatic cross sections when a TM (θ -polarized) wave illuminates the body broadside ($\theta = 90^\circ$). Repeat the analysis for a TE (ϕ -polarized) wave. For this calculation, assume that the body does not have an aperture.
- b) Calculate the electric and magnetic fields penetrating the aperture when the body is again illuminated broadside with a 10 MHz TM or TE wave, along a line bisecting the aperture (i.e., the incident angles for the wave are $\theta_i = 90^\circ$, $\phi_i = 22.5^\circ$). Sample the fields at the following points, measured in meters, within the cylinder along a line bisecting the aperture:

| ZTEST | YTEST | XTEST |
|-------|--------|---------|
| 0.0 | 0.248 | 7.0787 |
| 0.0 | 0.7439 | 8.276 |
| 0.0 | 1.2399 | 9.4734 |
| 0.0 | 1.7359 | 10.6707 |
| 0.0 | 2.4798 | 12.4667 |

and at the following points outside the aperture:

| | | |
|-----|-----|---------|
| 0.0 | 0.0 | 14.2560 |
| 0.0 | 0.0 | 19.44 |
| 0.0 | 0.0 | 71.28 |
| 0.0 | 0.0 | 150 |
| 0.0 | 0.0 | 300 |

Solution - The solution to the two parts of problem 1c was obtained by running BOTSCB, using BOTINV output from problem 1a as the input. In this analysis, the aperture was intercepted by two triangle functions. (For larger aperture angles, more triangle functions fall within the aperture

opening.) Figures 10 and 11 depict the coordinate file and partial listings of the inputs and outputs of BOTSCB. The bistatic scattering cross section for the apertureless body and the corresponding currents (partial listing) for θ and ϕ -polarized incident waves are given in Figures 11b and 11c, respectively. These outputs constitute the solution of the first part of problem 1c. The solution of the second part of the problem, involving the cylinder with the passive aperture, is summarized in Figure 11d.

```

10 14
17 30 .2094397E+00
0.0000 2.4798 4.5821 5.9867 6.4800 5.9857 4.5821 2.4798 -.0000 -2.4798 } Primary
-4.5821 -5.9867 -6.4800 -5.9857 -4.5821 -2.4798 0.0000 12.4667 12.9600 12.4667 } BOT
0.0000 .4933 1.8979 4.0002 6.4800 8.9598 11.0621 0.0000 data set
11.0621 8.9598 6.4800 4.0002 1.8979 .4933 0.0000
2 46 22.5000 93.0000 } Scattering angles and incident field
22.5 90.0
1 1
-27.9000 27.9000 4.5822 11.0620 -.0010 12.9590 -Aperture
10
.0000 .2480 7.0787
.0000 .7434 9.2760
.0000 1.2399 9.4734
.0000 1.7359 10.6707
.0000 2.4798 12.4667
0.0000 0.0000 14.2560
0.0000 0.0000 16.4400
0.0000 0.0000 18.2800
0.0000 0.0000 19.0000
0.0000 0.0000 20.0000
0.0000 0.0000 300.0000 } Near-field points

```

GP78-0451-42

Figure 10. Input data for execution of BOTSCB for problem 1c.

```

      NPT      NSAND      NMODE      NP      MC      BK
      20      14        4        17      50      .2094397E+00

YH
  0.0000  2.4798  4.5821  5.9867  6.4800  5.9857  4.5821  2.4798  0.0000 -2.4798
 -4.5821 -5.9867 -6.4800 -5.9867 -4.5821 -2.4798 0.0000

XH
  0.0000  8.4933  1.8979  4.0002  6.4800  8.4933  11.0621 12.4667 12.9600 12.4667
11.0621  8.4933  6.4800  4.0002  1.8979  0.4933  0.0000

```

HALF-LENGTH OF ROT = 41.4000

NUMBER OF FIXED ANGLES = 2

NUMBER OF ANGLES PER FIXED ANGLE = 46

FIXED ANGLE CODE(PHI FIXED = 1, THETA FIXED =2)

```

  22.5      1
  90.0      2

```

M= -3 N= -3

Y .9070311E-04 -.4701087E-03 .6824476E-04 -.5931252E-03

M= -2 N= -3

Y -.7578504E-04 .1106460E-04 -.5825230E-04 .2733491E-04

M= -1 N= -3

Y .8818303E-04 .1279038E-04 .6279109E-04 -.2656702E-04

M= 0 N= -3

Y -.1079845E-03 -.3263554E-04 -.6970442E-04 .2862848E-04

Figure 11a. Partial output of BOTSCB for problem 1c.

GP78-0481-43

[illegible]

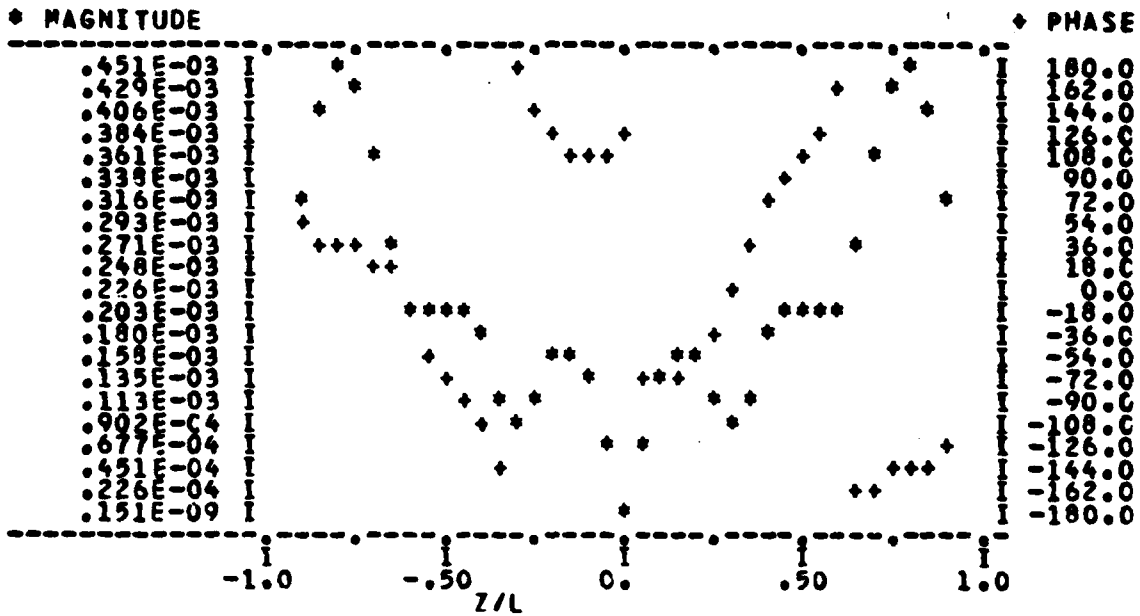
**t and z directed
current coefficients
for θ -polarized
incident field**

Figure 11b. Partial output of BOTSCB for problem 1c. (continued)

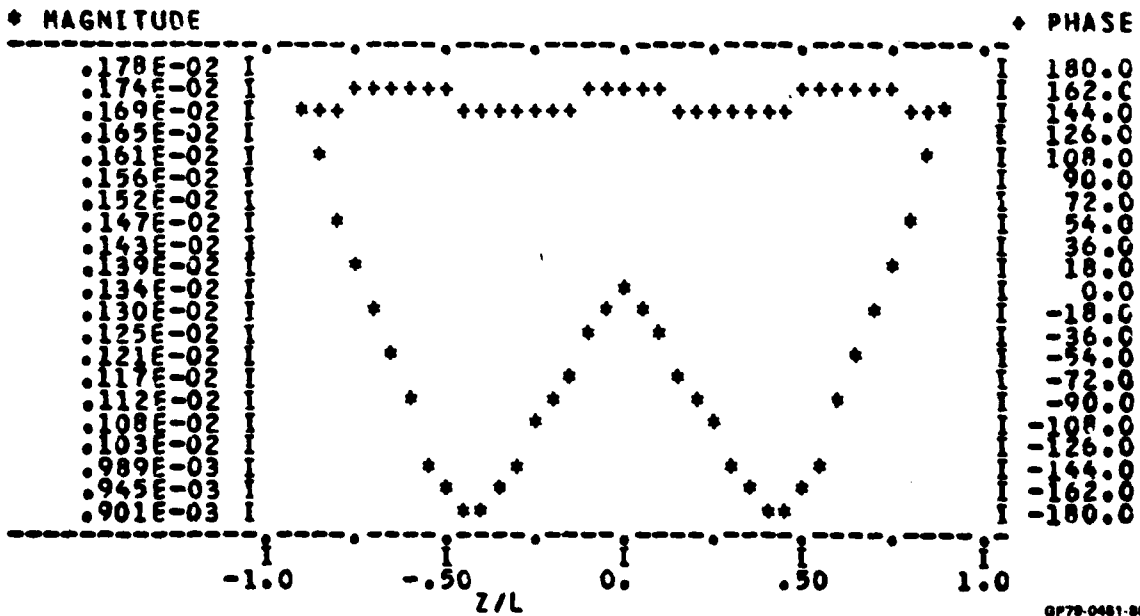
8879-0451-88

Plot of currents along BOT for
 θ -polarized incident field

T-DIRECTED CURRENTS ON TRIANGLE FUNCTION 1



Z-DIRECTED CURRENTS ON TRIANGLE FUNCTION 1



GP79-0481-08

Figure 11b. Partial output of BOTSCB for problem 1c. (concluded)

THE POLARIZED INCIDENT FIELD

| | | | | | | |
|---------------------------------|------------|------------|------------|------------|------------|------------|
| Y-DIRECTED CURRENTS FOR MODE -3 | -.1097E-03 | -.2745E-03 | -.1997E-03 | -.3944E-03 | -.3843E-04 | -.3263E-03 |
| Z-DIRECTED CURRENTS FOR MODE -3 | -.9120E-04 | -.2709E-03 | -.9231E-04 | -.2936E-03 | -.4121E-04 | -.7141E-03 |
| Y-DIRECTED CURRENTS FOR MODE -2 | -.1186E-03 | -.3106E-03 | -.1196E-03 | -.3136E-03 | -.1899E-03 | -.3989E-03 |
| Z-DIRECTED CURRENTS FOR MODE -2 | -.1194E-03 | -.3226E-03 | -.1174E-03 | -.3126E-03 | -.1799E-04 | -.3183E-03 |
| Y-DIRECTED CURRENTS FOR MODE -1 | -.1193E-03 | -.3174E-03 | -.1173E-03 | -.3136E-03 | -.3416E-03 | -.3788E-03 |
| Z-DIRECTED CURRENTS FOR MODE -1 | -.4189E-04 | -.5674E-04 | -.4146E-04 | -.5636E-04 | -.1888E-04 | -.7489E-04 |
| Y-DIRECTED CURRENTS FOR MODE 0 | -.1124E-03 | -.3293E-03 | -.1124E-03 | -.3233E-03 | -.3439E-03 | -.3763E-03 |
| Z-DIRECTED CURRENTS FOR MODE 0 | -.1124E-03 | -.3293E-03 | -.1124E-03 | -.3233E-03 | -.3439E-03 | -.3763E-03 |
| Y-DIRECTED CURRENTS FOR MODE 1 | -.1193E-03 | -.3174E-03 | -.1173E-03 | -.3136E-03 | -.3416E-03 | -.3788E-03 |
| Z-DIRECTED CURRENTS FOR MODE 1 | -.4189E-04 | -.5674E-04 | -.4146E-04 | -.5636E-04 | -.1888E-04 | -.7489E-04 |
| Y-DIRECTED CURRENTS FOR MODE 2 | -.1186E-03 | -.3106E-03 | -.1196E-03 | -.3136E-03 | -.1899E-03 | -.3989E-03 |
| Z-DIRECTED CURRENTS FOR MODE 2 | -.1194E-03 | -.3226E-03 | -.1174E-03 | -.3126E-03 | -.1799E-04 | -.3183E-03 |
| Y-DIRECTED CURRENTS FOR MODE 3 | -.1097E-03 | -.2745E-03 | -.1997E-03 | -.3944E-03 | -.3843E-04 | -.3263E-03 |
| Z-DIRECTED CURRENTS FOR MODE 3 | -.9120E-04 | -.2709E-03 | -.9231E-04 | -.2936E-03 | -.4121E-04 | -.7141E-03 |

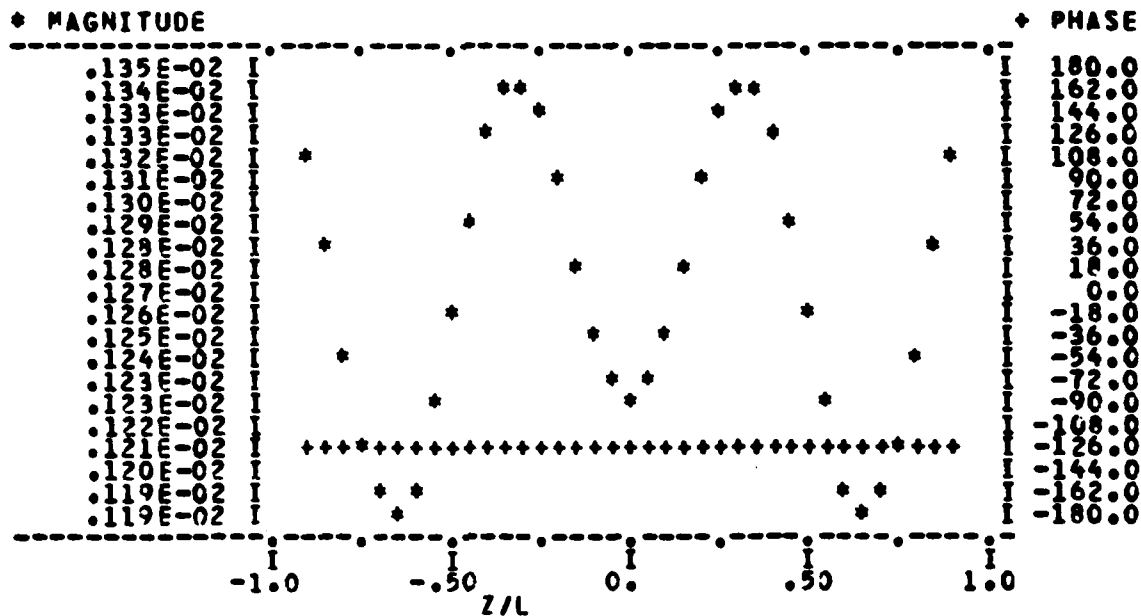
t and z
directed current
coefficients
for ϕ -polarized
incident field

GP79-0481-45

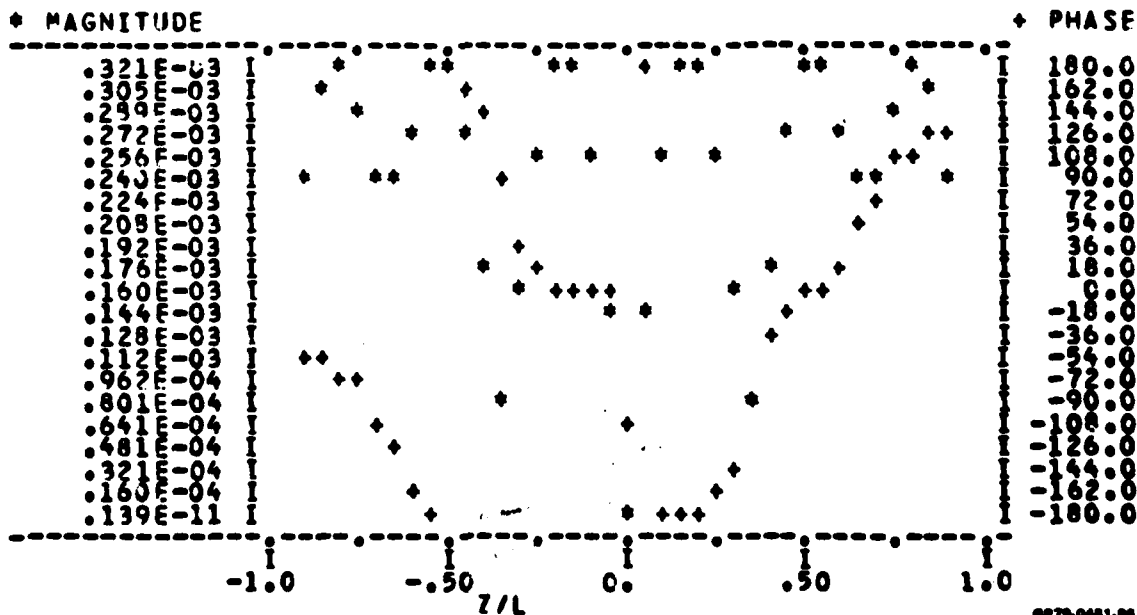
Figure 11c. Partial output of BOTSCB for problem 1c.

Plot of currents along BOT for
 ϕ -polarized incident field

T-DIRECTED CURRENTS ON TRIANGLE FUNCTION 1



Z-DIRECTED CURRENTS ON TRIANGLE FUNCTION 1



BP79-0481-06

Figure 11c. Partial output of BOTSCB for problem 1c. (concluded)

APERTURE ANALYSIS

Z_0 Z_1 Y_0 X_0 Y_1 X_1 Aperture coordinates
-27.9000 27.9000 4.9822 11.0620 -0.0610 12.9990

| LT | VLOW | VHGH | IT |
|----|--------|--------|----|
| 3 | .0001 | 2.5284 | -1 |
| 4 | 2.5284 | .0014 | 1 |

| LT | IT | FPP | | | | FPPZ | |
|----|----|-----------|-----------|-----------|-----------|-----------|-----------|
| 3 | -1 | .7821E-03 | .3751E+00 | .1250E+00 | .9777E-16 | .3750E+00 | .1250E+00 |
| 4 | 1 | .1250E+00 | .3756E+00 | .7821E-07 | .1250E+00 | .3751E+00 | .9777E-08 |

| YA1 | YA2 | YA3 | YA4 | |
|------------|------------|------------|------------|------------|
| -.5520E-03 | .1184E-16 | .3304E-16 | -.4213E-03 | Y_a^{tt} |
| -.4331E-03 | .3493E-16 | .2483E-16 | -.3107E-03 | Y_a^{zt} |
| -.1961E-02 | .4535E-16 | .1539E-16 | -.4090E-02 | Y_a^{tz} |
| -.5526E-03 | .1223E-16 | .2436E-16 | -.4318E-03 | Y_a^{zz} |
| -.6107E-03 | -.6022E-16 | -.5430E-16 | -.1628E-02 | |
| -.1963E-02 | -.1694E-16 | -.1641E-15 | -.4867E-02 | |

Aperture admittance

GP78-0451-46

Figure 11d. Partial output of BOTSCB for problem 1c.

NEAR FIELD ANALYSIS (for aperture-coupled fields)

| | | | | E-FIELD | | | | H-FIELD | | | |
|--------|--------|----------|-----------------|------------------|-----------|-----------|-----------------|------------------|-----------|-----------|--|
| | | | | FIELD COMPONENTS | | | | FIELD COMPONENTS | | | |
| ZTEST | YTEST | XTEST | | RADIAL | THETA | PHI | | RADIAL | THETA | PHI | |
| 0.0000 | .2480 | 7.0787 | INC POL E-FIELD | .1054E-07 | .2108E+00 | .3948E-08 | INC POL E-FIELD | .6444E-02 | .1222E-13 | .1788E-02 | |
| 0.0000 | .7430 | 9.2760 | INC POL E-FIELD | .1399E-07 | .4179E+00 | .6373E-08 | INC POL E-FIELD | .6718E-02 | .9175E-13 | .2188E-02 | |
| 0.0000 | 1.2399 | 9.4734 | INC POL E-FIELD | .1336E-07 | .6733E+00 | .7203E-08 | INC POL E-FIELD | .6988E-02 | .2609E-13 | .2604E-02 | |
| 0.0000 | 1.7359 | 10.6707 | INC POL E-FIELD | .2223E-07 | .9761E+00 | .6618E-08 | INC POL E-FIELD | .6933E-02 | .1303E-12 | .2931E-02 | |
| 0.0000 | 2.4798 | 12.4667 | INC POL E-FIELD | .1919E-07 | .4393E+00 | .8929E-08 | INC POL E-FIELD | .6890E-02 | .1766E-12 | .2188E-02 | |
| 0.0000 | 0.0000 | 14.2560 | INC POL E-FIELD | .7968E-08 | .9713E+00 | .8937E-07 | INC POL E-FIELD | .1181E-02 | .1622E-12 | .2188E-02 | |
| 0.0000 | 0.0000 | 19.4460 | INC POL E-FIELD | .1799E-08 | .8294E+00 | .8294E-07 | INC POL E-FIELD | .9090E-02 | .1177E-12 | .2188E-02 | |
| 0.0000 | 0.0000 | 71.2800 | INC POL E-FIELD | .1744E-09 | .8824E+00 | .1111E-08 | INC POL E-FIELD | .6799E-02 | .2828E-12 | .9017E-02 | |
| 0.0000 | 0.0000 | 150.0000 | INC POL E-FIELD | .1723E-10 | .1228E+00 | .8937E-09 | INC POL E-FIELD | .1187E-02 | .1377E-12 | .2188E-02 | |
| 0.0000 | 0.0000 | 300.0000 | INC POL E-FIELD | .1187E-10 | .9247E+00 | .2244E-09 | INC POL E-FIELD | .6396E-02 | .9735E-12 | .2188E-02 | |

GP78-0451-06

Figure 11d. Partial output of BOTSCB for problem 1c. (concluded)

Consider an asymmetric wing section of 2.76λ length, depicted subsequently in Figure 17, with coordinates specified in Figure 12. Use $NP = 17$ points to describe the body and let $NMODE = 4$. Compute the ϕ -polarized radiation patterns for a t-polarized axial slot antenna of 2.06λ length and 0.125λ width, centered about $Z = 0$, $X = 28.796$, and $Y = 26.085$. (The location of this slot corresponds to the eighth triangle function and is denoted as antenna A in Figure 17.) Carry out the analysis at 10 MHz.

Primary BOT data set

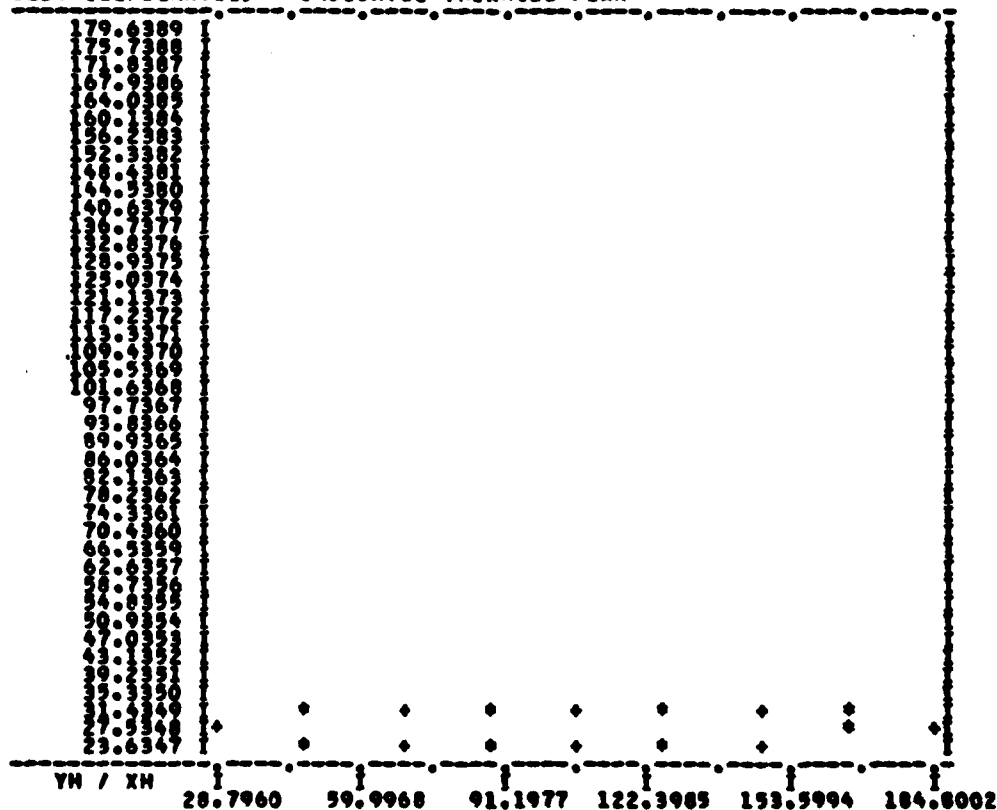
Radiation angles
Slot antenna
No near-field points

Figure 12. Input data for execution of BOTZSS, BOTINV, and BOTRA for problem 2.

GP79-0451-47

NPT 20 NSAMD 14 NMODE 4 NP 17 NC 50 BK .2013787E-01
 YH
 26.0850 31.0710 32.3539 32.9255 32.0293 32.9265 31.8038 30.7098 28.0930 25.7583
 24.8911 24.1096 23.6470 23.6347 24.0250 24.7786 26.0890
 XH
 28.7960 48.2965 67.7971 87.2976 106.7981 126.2986 145.7992 165.2997 184.8002 165.2997
 145.7992 126.2986 106.7981 87.2976 67.7971 48.2965 28.7960

BODY COORDINATES, + INDICATES TRIANGLE PEAK



HALF-LENGTH OF BOT = 430.5716

GP79-0481-48

Figure 13. Partial output of BOTZSS for problem 2.

[illegible]

THE MINIMUM DIMENSIONS ARE AS FOLLOWS:

| | | | | |
|-------|-----|------|----|-----|
| 2 | 11 | WORK | 17 | 112 |
| 12944 | 256 | 0 | 0 | 112 |

3-3-3-3

| Admittance matrix | $Y_{3,3}^{tt}$ | $Y_{3,3}^{zt}$ |
|-------------------|----------------|----------------|
| 0.1009E-04 | -0.2793E-02 | 0.4730E-03 |
| 0.1710E-04 | -0.1493E-02 | 0.7404E-03 |
| 0.3018E-04 | -0.3009E-02 | 0.1040E-04 |
| 0.3074E-04 | -0.3644E-02 | 0.3039E-04 |
| 0.3039E-04 | -0.3009E-02 | 0.3914E-04 |
| 0.1709E-04 | -0.1404E-02 | 0.3743E-04 |
| 0.2033E-04 | -0.2792E-02 | 0.2043E-04 |
| 0.3708E-07 | -0.0035E-03 | 0.2121E-04 |
| 0.0427E-03 | 0.3932E-04 | 0.1140E-02 |
| 0.1144E-02 | 0.5270E-04 | -0.2507E-02 |
| 0.2666E-02 | 0.9126E-04 | -0.1631E-02 |
| 0.1020E-04 | -0.3219E-03 | 0.1619E-01 |
| 0.2765E-02 | 0.9094E-04 | -0.3940E-03 |
| 0.1170E-02 | 0.5064E-04 | -0.1426E-03 |
| 0.8394E-03 | -0.4318E-04 | -0.3395E-02 |
| 0.6377E-04 | -0.4012E-03 | 0.2415E-02 |
| | | -0.6949E-04 |

9279-0451-49

Figure 14. Partial output of BOTINV for problem 2.

TOTAL POWER(DB) = -5.17

| PHI | THETA | POWER(DB) | |
|-------|-------|-----------|--------|
| | | 0 | 90 |
| 0.0 | 90.0 | -235.48 | -75.99 |
| 4.0 | 90.0 | -233.23 | -76.05 |
| 8.0 | 90.0 | -230.15 | -76.13 |
| 12.0 | 90.0 | -227.52 | -76.22 |
| 16.0 | 90.0 | -225.40 | -76.32 |
| 20.0 | 90.0 | -223.65 | -76.45 |
| 24.0 | 90.0 | -222.18 | -76.60 |
| 28.0 | 90.0 | -220.91 | -76.77 |
| 32.0 | 90.0 | -219.81 | -76.97 |
| 36.0 | 90.0 | -218.83 | -77.21 |
| 40.0 | 90.0 | -217.96 | -77.47 |
| 44.0 | 90.0 | -217.18 | -77.78 |
| 48.0 | 90.0 | -216.49 | -78.11 |
| 52.0 | 90.0 | -215.87 | -78.48 |
| 56.0 | 90.0 | -215.33 | -78.86 |
| 60.0 | 90.0 | -214.84 | -79.26 |
| 64.0 | 90.0 | -214.43 | -79.66 |
| 68.0 | 90.0 | -214.07 | -80.02 |
| 72.0 | 90.0 | -213.78 | -80.33 |
| 76.0 | 90.0 | -213.54 | -80.54 |
| 80.0 | 90.0 | -213.36 | -80.63 |
| 84.0 | 90.0 | -213.24 | -80.59 |
| 88.0 | 90.0 | -213.18 | -80.42 |
| 92.0 | 90.0 | -213.18 | -80.14 |
| 96.0 | 90.0 | -213.23 | -79.77 |
| 100.0 | 90.0 | -213.35 | -79.36 |
| 104.0 | 90.0 | -213.52 | -78.92 |
| 108.0 | 90.0 | -213.75 | -78.48 |
| 112.0 | 90.0 | -214.04 | -78.06 |
| 116.0 | 90.0 | -214.40 | -77.67 |
| 120.0 | 90.0 | -214.82 | -77.31 |
| 124.0 | 90.0 | -215.30 | -76.99 |
| 128.0 | 90.0 | -215.85 | -76.70 |
| 132.0 | 90.0 | -216.48 | -76.46 |
| 136.0 | 90.0 | -217.18 | -76.25 |
| 140.0 | 90.0 | -217.97 | -76.07 |
| 144.0 | 90.0 | -218.86 | -75.92 |
| 148.0 | 90.0 | -219.87 | -75.81 |
| 152.0 | 90.0 | -221.01 | -75.71 |
| 156.0 | 90.0 | -222.33 | -75.64 |
| 160.0 | 90.0 | -223.84 | -75.59 |
| 164.0 | 90.0 | -225.75 | -75.56 |
| 168.0 | 90.0 | -228.00 | -75.54 |
| 172.0 | 90.0 | -231.21 | -75.53 |
| 176.0 | 90.0 | -235.63 | -75.53 |
| 180.0 | 90.0 | -240.20 | -75.54 |

Power radiation patterns

Roll plane ($\theta = 90^\circ$)

GP79-0461-81

Figure 16a. Partial output of BOTRA for problem 2.

| PHI | THETA | POWER (DB) | |
|-------|-------|------------|--------|
| | | • | • |
| 0.0 | -90.0 | -240.20 | -75.54 |
| 4.0 | -90.0 | -236.50 | -75.56 |
| 8.0 | -90.0 | -231.82 | -75.60 |
| 12.0 | -90.0 | -228.54 | -75.64 |
| 16.0 | -90.0 | -226.11 | -75.70 |
| 20.0 | -90.0 | -224.18 | -75.77 |
| 24.0 | -90.0 | -222.60 | -75.86 |
| 28.0 | -90.0 | -221.25 | -75.96 |
| 32.0 | -90.0 | -220.09 | -76.09 |
| 36.0 | -90.0 | -219.06 | -76.24 |
| 40.0 | -90.0 | -218.16 | -76.41 |
| 44.0 | -90.0 | -217.35 | -76.61 |
| 48.0 | -90.0 | -216.63 | -76.83 |
| 52.0 | -90.0 | -215.99 | -77.08 |
| 56.0 | -90.0 | -215.42 | -77.34 |
| 60.0 | -90.0 | -214.93 | -77.61 |
| 64.0 | -90.0 | -214.49 | -77.89 |
| 68.0 | -90.0 | -214.12 | -78.14 |
| 72.0 | -90.0 | -213.82 | -78.37 |
| 76.0 | -90.0 | -213.57 | -78.57 |
| 80.0 | -90.0 | -213.38 | -78.70 |
| 84.0 | -90.0 | -213.25 | -78.77 |
| 88.0 | -90.0 | -213.19 | -78.77 |
| 92.0 | -90.0 | -213.18 | -78.69 |
| 96.0 | -90.0 | -213.23 | -78.55 |
| 100.0 | -90.0 | -213.33 | -78.35 |
| 104.0 | -90.0 | -213.50 | -78.12 |
| 108.0 | -90.0 | -213.73 | -77.87 |
| 112.0 | -90.0 | -214.03 | -77.60 |
| 116.0 | -90.0 | -214.38 | -77.34 |
| 120.0 | -90.0 | -214.80 | -77.10 |
| 124.0 | -90.0 | -215.29 | -76.87 |
| 128.0 | -90.0 | -215.84 | -76.66 |
| 132.0 | -90.0 | -216.47 | -76.48 |
| 136.0 | -90.0 | -217.18 | -76.32 |
| 140.0 | -90.0 | -217.97 | -76.19 |
| 144.0 | -90.0 | -218.87 | -76.08 |
| 148.0 | -90.0 | -219.88 | -76.00 |
| 152.0 | -90.0 | -221.03 | -75.94 |
| 156.0 | -90.0 | -222.35 | -75.91 |
| 160.0 | -90.0 | -223.89 | -75.88 |
| 164.0 | -90.0 | -225.73 | -75.88 |
| 168.0 | -90.0 | -227.97 | -75.89 |
| 172.0 | -90.0 | -230.75 | -75.91 |
| 176.0 | -90.0 | -233.92 | -75.95 |
| 180.0 | -90.0 | -235.48 | -75.99 |

Roll plane
($\theta = -90^\circ$)

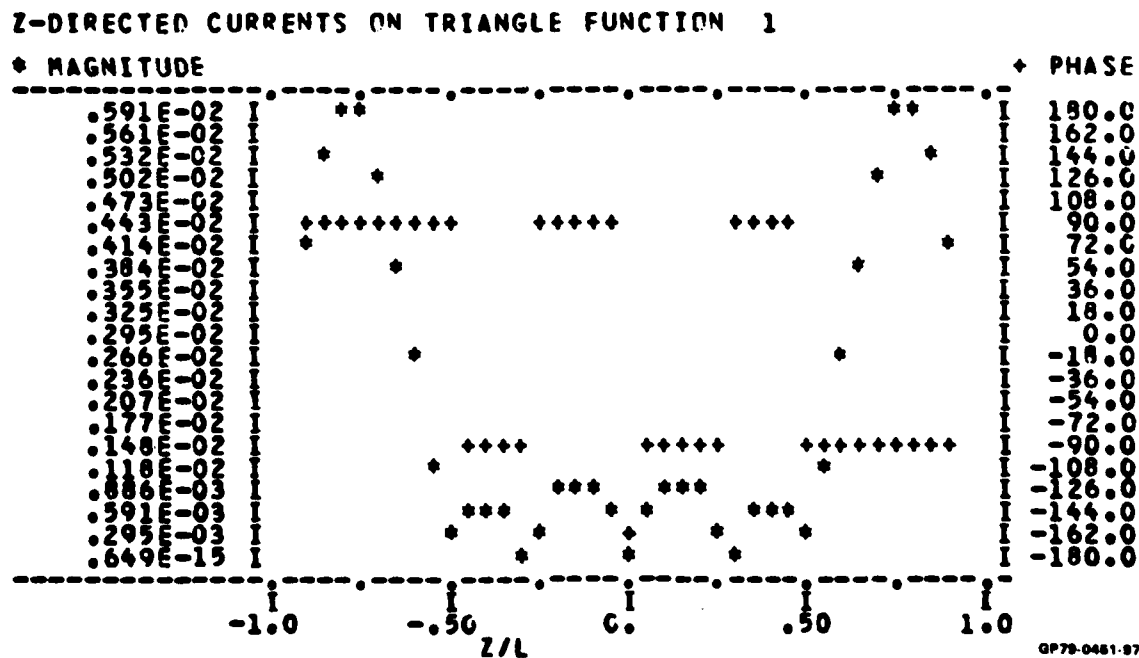
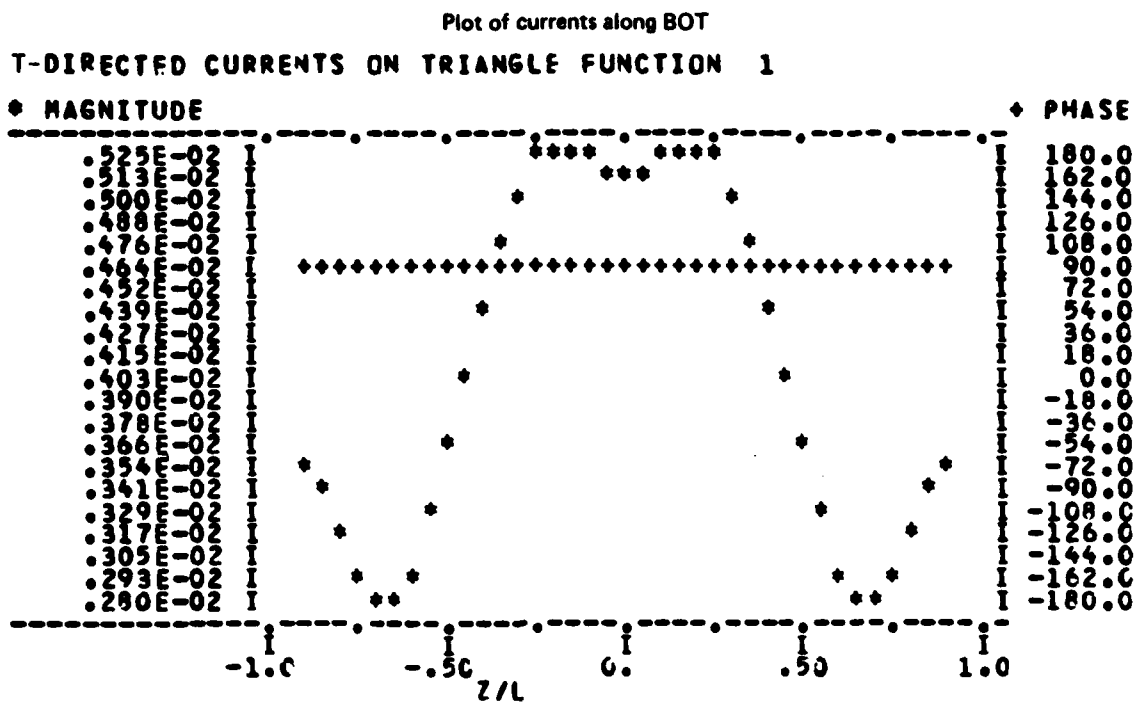
GP78-0481-00

Figure 16a. Partial output of BOTRA for problem 2. (concluded)

| | | | t and z | | | directed | | | current | | | coefficients | | |
|---------------------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|--------------|------------|------------|
| | | | | | | | | | | | | | | |
| T-DIRECTED CURRENTS FOR MODE -3 | | | | | | | | | | | | | | |
| -0.110E-03 | -0.377E-03 | -0.368E-03 | -0.941E-03 | -0.323E-03 | -0.319E-03 | -0.377E-03 | -0.368E-03 | -0.377E-03 | -0.368E-03 | -0.377E-03 | -0.368E-03 | -0.377E-03 | -0.368E-03 | -0.377E-03 |
| Z-DIRECTED CURRENTS FOR MODE -3 | | | | | | | | | | | | | | |
| -0.109E-03 | -0.370E-03 | -0.360E-03 | -0.931E-03 | -0.314E-03 | -0.311E-03 | -0.370E-03 | -0.360E-03 | -0.370E-03 | -0.360E-03 | -0.370E-03 | -0.360E-03 | -0.370E-03 | -0.360E-03 | -0.370E-03 |
| Y-DIRECTED CURRENTS FOR MODE -2 | | | | | | | | | | | | | | |
| -0.108E-03 | -0.361E-03 | -0.350E-03 | -0.921E-03 | -0.305E-03 | -0.302E-03 | -0.361E-03 | -0.350E-03 | -0.361E-03 | -0.350E-03 | -0.361E-03 | -0.350E-03 | -0.361E-03 | -0.350E-03 | -0.361E-03 |
| Z-DIRECTED CURRENTS FOR MODE -2 | | | | | | | | | | | | | | |
| -0.107E-03 | -0.352E-03 | -0.341E-03 | -0.911E-03 | -0.296E-03 | -0.293E-03 | -0.352E-03 | -0.341E-03 | -0.352E-03 | -0.341E-03 | -0.352E-03 | -0.341E-03 | -0.352E-03 | -0.341E-03 | -0.352E-03 |
| T-DIRECTED CURRENTS FOR MODE -1 | | | | | | | | | | | | | | |
| -0.106E-03 | -0.343E-03 | -0.332E-03 | -0.901E-03 | -0.287E-03 | -0.284E-03 | -0.343E-03 | -0.332E-03 | -0.343E-03 | -0.332E-03 | -0.343E-03 | -0.332E-03 | -0.343E-03 | -0.332E-03 | -0.343E-03 |
| Z-DIRECTED CURRENTS FOR MODE -1 | | | | | | | | | | | | | | |
| -0.105E-03 | -0.334E-03 | -0.323E-03 | -0.891E-03 | -0.278E-03 | -0.275E-03 | -0.334E-03 | -0.323E-03 | -0.334E-03 | -0.323E-03 | -0.334E-03 | -0.323E-03 | -0.334E-03 | -0.323E-03 | -0.334E-03 |
| T-DIRECTED CURRENTS FOR MODE 0 | | | | | | | | | | | | | | |
| -0.104E-03 | -0.325E-03 | -0.314E-03 | -0.881E-03 | -0.269E-03 | -0.266E-03 | -0.325E-03 | -0.314E-03 | -0.325E-03 | -0.314E-03 | -0.325E-03 | -0.314E-03 | -0.325E-03 | -0.314E-03 | -0.325E-03 |
| Z-DIRECTED CURRENTS FOR MODE 0 | | | | | | | | | | | | | | |
| -0.103E-03 | -0.316E-03 | -0.305E-03 | -0.871E-03 | -0.260E-03 | -0.257E-03 | -0.316E-03 | -0.305E-03 | -0.316E-03 | -0.305E-03 | -0.316E-03 | -0.305E-03 | -0.316E-03 | -0.305E-03 | -0.316E-03 |
| T-DIRECTED CURRENTS FOR MODE 1 | | | | | | | | | | | | | | |
| -0.102E-03 | -0.307E-03 | -0.296E-03 | -0.861E-03 | -0.251E-03 | -0.248E-03 | -0.307E-03 | -0.296E-03 | -0.307E-03 | -0.296E-03 | -0.307E-03 | -0.296E-03 | -0.307E-03 | -0.296E-03 | -0.307E-03 |
| Z-DIRECTED CURRENTS FOR MODE 1 | | | | | | | | | | | | | | |
| -0.101E-03 | -0.298E-03 | -0.287E-03 | -0.851E-03 | -0.242E-03 | -0.239E-03 | -0.298E-03 | -0.287E-03 | -0.298E-03 | -0.287E-03 | -0.298E-03 | -0.287E-03 | -0.298E-03 | -0.287E-03 | -0.298E-03 |
| T-DIRECTED CURRENTS FOR MODE 2 | | | | | | | | | | | | | | |
| -0.100E-03 | -0.289E-03 | -0.278E-03 | -0.841E-03 | -0.233E-03 | -0.230E-03 | -0.289E-03 | -0.278E-03 | -0.289E-03 | -0.278E-03 | -0.289E-03 | -0.278E-03 | -0.289E-03 | -0.278E-03 | -0.289E-03 |
| Z-DIRECTED CURRENTS FOR MODE 2 | | | | | | | | | | | | | | |
| -0.099E-03 | -0.280E-03 | -0.269E-03 | -0.831E-03 | -0.224E-03 | -0.221E-03 | -0.280E-03 | -0.269E-03 | -0.280E-03 | -0.269E-03 | -0.280E-03 | -0.269E-03 | -0.280E-03 | -0.269E-03 | -0.280E-03 |
| T-DIRECTED CURRENTS FOR MODE 3 | | | | | | | | | | | | | | |
| -0.098E-03 | -0.271E-03 | -0.260E-03 | -0.821E-03 | -0.215E-03 | -0.212E-03 | -0.271E-03 | -0.260E-03 | -0.271E-03 | -0.260E-03 | -0.271E-03 | -0.260E-03 | -0.271E-03 | -0.260E-03 | -0.271E-03 |
| Z-DIRECTED CURRENTS FOR MODE 3 | | | | | | | | | | | | | | |
| -0.097E-03 | -0.262E-03 | -0.251E-03 | -0.811E-03 | -0.206E-03 | -0.203E-03 | -0.262E-03 | -0.251E-03 | -0.262E-03 | -0.251E-03 | -0.262E-03 | -0.251E-03 | -0.262E-03 | -0.251E-03 | -0.262E-03 |

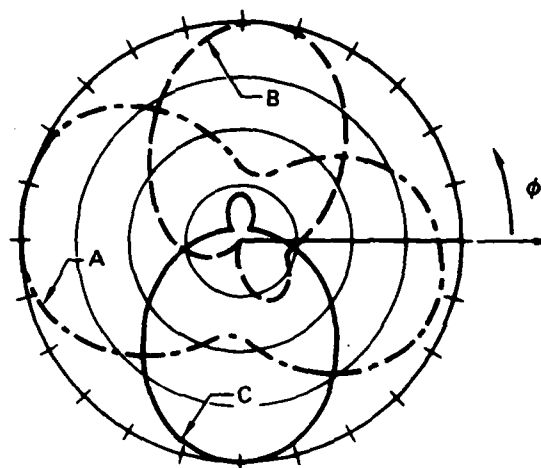
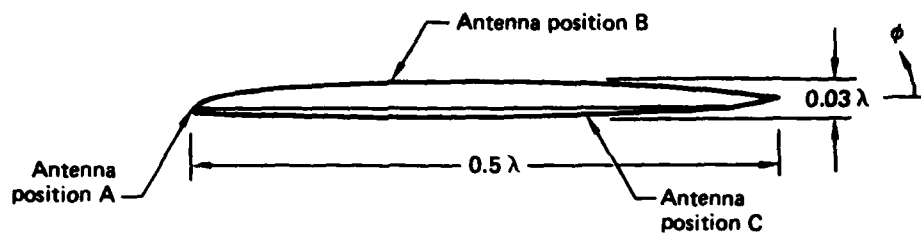
0979-0461-82

Figure 16b. Partial output of BOTRA for problem 2.



GP79-0461-97

Figure 16b. Partial output of BOTRA for problem 2. (concluded)



Radiated power calculated for
axial slot (2.06λ long)
 ϕ polarization

GP75-0481-83

Figure 17. Computed radiation patterns for wing section.

2.6.5 Problem 3

Consider a square cylinder with sides 0.3183λ and a length of 2.76λ . Illuminate the cylinder broadside ($\theta = 90^\circ$) with a TM (θ -polarized) wave. Repeat the analysis for a TE (ϕ -polarized) wave.

- Compute the resulting bistatic cross sections for all polarizations both in the horizontal ($\phi = 0^\circ$) plane and the roll ($\theta = 90^\circ$) plane at 46(NT) equi-spaced angles.
- Compute the magnitude and phase of the currents induced by the TM and TE illumination.

Solution - The calculations were carried out at 10 MHz ($\lambda = 30$ m). The body was represented by 17(NP) coordinate points, and 4(NMODE) modes were used. The coordinate points are such that the corners of the cylinder correspond to triangle function peaks. This restriction is necessary to obtain proper accuracy in the calculations. The execution of BOTSEG is shown in Figure 18a in the time-share mode. Input data to execute BOTZSS, BOTINV, and BOTSCB are summarized in Figure 18b. Partial listings of the inputs and outputs for these programs are given in Figures 19-21.

The results for the two parts of this problem are given in Figures 21b and 21c. Comparison of the bistatic scattering results using the present analysis with published data is summarized in Figure 15 of Volume I. The aperture penetration and near-field analysis options were not exercised in this problem.

| | | | | |
|---|--------|----|---------|------------|
| ? | 6 | 17 | | (2I3) |
| ? | 0.0 | | 0.0 | } (4E10.4) |
| ? | 0.0 | | 4.7745 | |
| ? | 9.5490 | | 4.7745 | |
| ? | 9.5490 | | -4.7745 | |
| ? | 0.0 | | -4.7745 | |
| ? | 0.0 | | 0.0 | |

NP = 17.

| | | | | | | | | | | |
|-----------|---------|---------|---------|---------|---------|---------|--------|--------|--------|---------|
| YH | 0.0000 | 2.3873 | 4.7745 | 4.7745 | 4.7745 | 4.7745 | 4.7745 | 2.3873 | 0.0000 | -2.3873 |
| | -4.7745 | -4.7745 | -4.7745 | -4.7745 | -4.7745 | -2.3873 | 0.0000 | | | |
| XH | 0.0000 | 0.0000 | 0.0000 | 2.3873 | 4.7745 | 7.1618 | 9.5490 | 9.5490 | 9.5490 | 9.5490 |
| | 9.5490 | 7.1618 | 4.7745 | 2.3873 | .0000 | 0.0000 | 0.0000 | | | |

BODY COORDINATES + INDICATES TRIANGLE PEAK

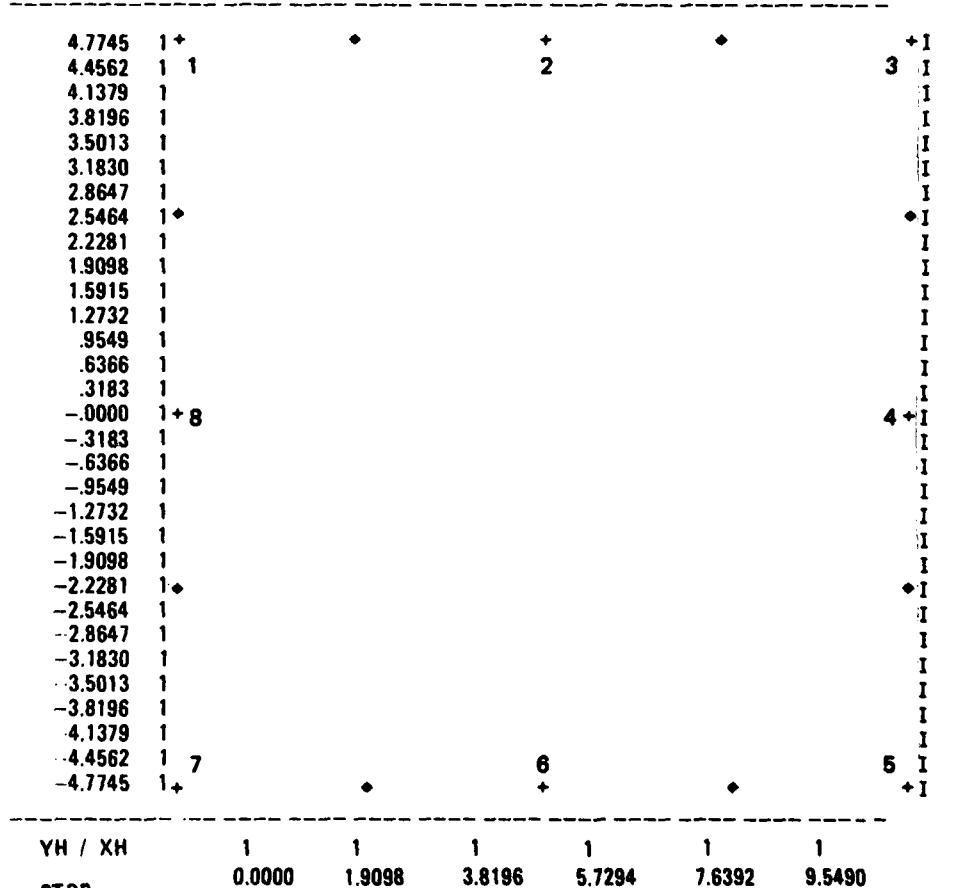


Figure 18a. Execution of BOTSEG for problem 3, with triangle functions numbered on the plot.

| | NPT 20 | NBAND 14 | NMODE 4 | NP 17 | MC 50 | BK .2094397E+00 | | | | |
|----|-----------|-------------|------------|----------|----------|--------------------|--------|--------|--------|---------|
| YH | 0.0000 | 2.3873 | 4.7745 | 4.7745 | 4.7745 | 4.7745 | 4.7745 | 2.3873 | 0.0000 | -2.3873 |
| | -4.7745 | -4.7745 | -4.7745 | -4.7745 | -4.7745 | -2.3873 | 0.0000 | | | |
| XH | 0.0000 | 0.0000 | 0.0000 | 2.3873 | 4.7745 | 7.1618 | 9.5490 | 9.5490 | 9.5490 | 9.5490 |
| | 9.5490 | 7.1618 | 4.7745 | 2.3873 | 0.0000 | 0.0000 | 0.0000 | | | |

HALF-LENGTH OF BOT = 41.4000

NUMBER OF FIXED ANGLES = 2

NUMBER OF ANGLES PER FIXED ANGLE = 46

FIXED ANGLE CODE(PHI FIXED = 1, THETA FIXED =2)

| | |
|------|---|
| 0.0 | 1 |
| 90.0 | 2 |

M= -3 N= -3

Y .7189509E-04 -.6033521E-03 .6005373E-04 -.6739350E-03

M= -2 N= -3

Y -.6336747E-04 .6889634E-06 -.4920743E-04 .1958407E-04

M= -1 N= -3

Y .7044501E-04 .2308832E-04 .4977628E-04 -.1812870E-04

M= 0 N= -3

Y -.8299667E-04 -.4713423E-04 -.5359391E-04 .1778258E-04

GP79-0481-88

Figure 21a. Partial output of BOTSCB for problem 3.

| BI-STATIC RCS(00). INCIDENT PHI = 0.0 THETA = 90.0 | | | | | |
|--|-------|--------|--------|--------|--------|
| PHI | THETA | 00 | 00 | 00 | 00 |
| 0.0 | 0.0 | -14.82 | -11.27 | -61.35 | -76.63 |
| 0.0 | 4.0 | -17.06 | -11.02 | -60.86 | -76.14 |
| 0.0 | 8.0 | -17.06 | -10.15 | -59.74 | -75.14 |
| 0.0 | 12.0 | -9.06 | -8.86 | -58.25 | -74.84 |
| 0.0 | 16.0 | -9.06 | -7.40 | -56.67 | -74.00 |
| 0.0 | 20.0 | -8.86 | -6.02 | -55.15 | -73.30 |
| 0.0 | 24.0 | -8.86 | -4.91 | -54.18 | -72.55 |
| 0.0 | 28.0 | -10.15 | -4.23 | -53.65 | -71.87 |
| 0.0 | 32.0 | -10.15 | -4.15 | -53.64 | -71.35 |
| 0.0 | 36.0 | -13.01 | -4.63 | -53.10 | -71.03 |
| 0.0 | 40.0 | -13.01 | -6.62 | -53.11 | -71.03 |
| 0.0 | 44.0 | -13.01 | -9.64 | -64.67 | -71.42 |
| 0.0 | 48.0 | -13.01 | -11.44 | -64.67 | -72.37 |
| 0.0 | 52.0 | -7.40 | -9.45 | -57.86 | -74.08 |
| 0.0 | 56.0 | -4.91 | -8.86 | -55.11 | -76.86 |
| 0.0 | 60.0 | -4.91 | -4.81 | -54.91 | -80.02 |
| 0.0 | 64.0 | -4.91 | -4.23 | -57.49 | -82.82 |
| 0.0 | 68.0 | -17.37 | -10.18 | -65.97 | -79.65 |
| 0.0 | 72.0 | -17.37 | -6.23 | -64.38 | -77.17 |
| 0.0 | 76.0 | -5.08 | -4.28 | -57.20 | -76.38 |
| 0.0 | 80.0 | -5.08 | 3.62 | -55.10 | -77.28 |
| 0.0 | 84.0 | 10.15 | 5.84 | -57.37 | -80.45 |
| 0.0 | 88.0 | 10.15 | 6.94 | -65.72 | -86.38 |
| 0.0 | 92.0 | 10.15 | 6.94 | -65.72 | -86.38 |
| 0.0 | 96.0 | 7.40 | 3.89 | -57.37 | -80.45 |
| 0.0 | 100.0 | 2.41 | 3.62 | -55.10 | -77.28 |
| 0.0 | 104.0 | 2.41 | -1.28 | -57.20 | -76.38 |
| 0.0 | 108.0 | -5.08 | -6.63 | -64.38 | -77.17 |
| 0.0 | 112.0 | -17.37 | -10.18 | -65.97 | -79.65 |
| 0.0 | 116.0 | -17.37 | -6.23 | -64.38 | -82.82 |
| 0.0 | 120.0 | -9.06 | -4.81 | -54.91 | -80.02 |
| 0.0 | 124.0 | -9.06 | -3.68 | -55.11 | -76.86 |
| 0.0 | 128.0 | -10.15 | -3.68 | -57.86 | -74.08 |
| 0.0 | 132.0 | -13.01 | -11.44 | -64.67 | -72.37 |
| 0.0 | 136.0 | -13.01 | -9.64 | -64.67 | -71.42 |
| 0.0 | 140.0 | -13.01 | -6.62 | -53.11 | -71.03 |
| 0.0 | 144.0 | -13.01 | -4.85 | -55.10 | -71.03 |
| 0.0 | 148.0 | -10.15 | -4.15 | -53.64 | -71.35 |
| 0.0 | 152.0 | -9.06 | -4.23 | -53.65 | -71.87 |
| 0.0 | 156.0 | -8.86 | -4.91 | -54.18 | -72.55 |
| 0.0 | 160.0 | -8.86 | -6.02 | -55.15 | -73.30 |
| 0.0 | 164.0 | -9.06 | -7.40 | -56.67 | -74.00 |
| 0.0 | 168.0 | -9.06 | -8.86 | -58.25 | -74.84 |
| 0.0 | 172.0 | -11.02 | -10.15 | -59.74 | -75.14 |
| 0.0 | 176.0 | -12.68 | -11.02 | -60.86 | -76.14 |
| 0.0 | 180.0 | -14.82 | -11.27 | -61.35 | -76.63 |

Plane at $\phi = 0^\circ$

0770-0451-50

Figure 21b. Partial output of BOTSCB for problem 3.

THETA POLARIZED INCIDENT FIELD

| | | | | | | | |
|---------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| T-DIRECTED CURRENTS FOR MODE -3 | -0724E-04 | -2204E-03 | -1015E-03 | -1403E-03 | -1381E-04 | -1493E-06 | -1031E-03 |
| -1034E-03 | -1239E-04 | -2204E-03 | -1015E-03 | -1403E-03 | -1381E-04 | -1493E-06 | -1031E-03 |
| -1480E-03 | -1239E-04 | -2204E-03 | -1015E-03 | -1403E-03 | -1381E-04 | -1493E-06 | -1031E-03 |
| Z-DIRECTED CURRENTS FOR MODE -3 | -1445E-03 | -3377E-03 | -2175E-03 | -3135E-03 | -2021E-03 | -3999E-06 | -3901E-03 |
| -1725E-03 | -1507E-03 | -3377E-03 | -2175E-03 | -3135E-03 | -2021E-03 | -3999E-06 | -3901E-03 |
| -3060E-03 | -1507E-03 | -3377E-03 | -2175E-03 | -3135E-03 | -2021E-03 | -3999E-06 | -3901E-03 |
| T-DIRECTED CURRENTS FOR MODE -2 | -1019E-03 | -3288E-04 | -1967E-03 | -6202E-04 | -1908E-03 | -2609E-06 | -2379E-06 |
| -1299E-04 | -1019E-03 | -3288E-04 | -1967E-03 | -6202E-04 | -1908E-03 | -2609E-06 | -2379E-06 |
| -1299E-04 | -1019E-03 | -3288E-04 | -1967E-03 | -6202E-04 | -1908E-03 | -2609E-06 | -2379E-06 |
| Z-DIRECTED CURRENTS FOR MODE -2 | -1019E-03 | -3288E-04 | -1967E-03 | -6202E-04 | -1908E-03 | -2609E-06 | -2379E-06 |
| -1019E-03 | -3288E-04 | -1967E-03 | -6202E-04 | -1908E-03 | -1908E-03 | -2609E-06 | -2379E-06 |
| -1019E-03 | -3288E-04 | -1967E-03 | -6202E-04 | -1908E-03 | -1908E-03 | -2609E-06 | -2379E-06 |
| T-DIRECTED CURRENTS FOR MODE -1 | -1775E-04 | -722E-03 | -9108E-04 | -1877E-04 | -5103E-04 | -7204E-07 | -1875E-06 |
| -1819E-04 | -722E-03 | -9108E-04 | -1877E-04 | -1877E-04 | -5103E-04 | -7204E-07 | -1875E-06 |
| -1819E-04 | -722E-03 | -9108E-04 | -1877E-04 | -1877E-04 | -5103E-04 | -7204E-07 | -1875E-06 |
| Z-DIRECTED CURRENTS FOR MODE -1 | -1775E-04 | -722E-03 | -9108E-04 | -1877E-04 | -5103E-04 | -7204E-07 | -1875E-06 |
| -1775E-04 | -722E-03 | -9108E-04 | -1877E-04 | -1877E-04 | -5103E-04 | -7204E-07 | -1875E-06 |
| -1775E-04 | -722E-03 | -9108E-04 | -1877E-04 | -1877E-04 | -5103E-04 | -7204E-07 | -1875E-06 |
| T-DIRECTED CURRENTS FOR MODE 0 | -1836E-10 | -1037E-09 | -2625E-09 | -1614E-09 | -1032E-09 | -1024E-11 | -1424E-12 |
| -1836E-10 | -1037E-09 | -2625E-09 | -1614E-09 | -1032E-09 | -1032E-09 | -1024E-11 | -1424E-12 |
| -1836E-10 | -1037E-09 | -2625E-09 | -1614E-09 | -1032E-09 | -1032E-09 | -1024E-11 | -1424E-12 |
| Z-DIRECTED CURRENTS FOR MODE 0 | -1836E-10 | -1037E-09 | -2625E-09 | -1614E-09 | -1032E-09 | -1024E-11 | -1424E-12 |
| -1836E-10 | -1037E-09 | -2625E-09 | -1614E-09 | -1032E-09 | -1032E-09 | -1024E-11 | -1424E-12 |
| -1836E-10 | -1037E-09 | -2625E-09 | -1614E-09 | -1032E-09 | -1032E-09 | -1024E-11 | -1424E-12 |
| T-DIRECTED CURRENTS FOR MODE 1 | -1775E-04 | -722E-03 | -9108E-04 | -1877E-04 | -5103E-04 | -7204E-07 | -1875E-06 |
| -1775E-04 | -722E-03 | -9108E-04 | -1877E-04 | -1877E-04 | -5103E-04 | -7204E-07 | -1875E-06 |
| -1775E-04 | -722E-03 | -9108E-04 | -1877E-04 | -1877E-04 | -5103E-04 | -7204E-07 | -1875E-06 |
| Z-DIRECTED CURRENTS FOR MODE 1 | -1775E-04 | -722E-03 | -9108E-04 | -1877E-04 | -5103E-04 | -7204E-07 | -1875E-06 |
| -1775E-04 | -722E-03 | -9108E-04 | -1877E-04 | -1877E-04 | -5103E-04 | -7204E-07 | -1875E-06 |
| -1775E-04 | -722E-03 | -9108E-04 | -1877E-04 | -1877E-04 | -5103E-04 | -7204E-07 | -1875E-06 |
| T-DIRECTED CURRENTS FOR MODE 2 | -1539E-03 | -1944E-03 | -1479E-03 | -3078E-04 | -4301E-04 | -1553E-03 | -5905E-04 |
| -1539E-03 | -1944E-03 | -1479E-03 | -3078E-04 | -4301E-04 | -4301E-04 | -1553E-03 | -5905E-04 |
| -1539E-03 | -1944E-03 | -1479E-03 | -3078E-04 | -4301E-04 | -4301E-04 | -1553E-03 | -5905E-04 |
| Z-DIRECTED CURRENTS FOR MODE 2 | -1539E-03 | -1944E-03 | -1479E-03 | -3078E-04 | -4301E-04 | -1553E-03 | -5905E-04 |
| -1539E-03 | -1944E-03 | -1479E-03 | -3078E-04 | -4301E-04 | -4301E-04 | -1553E-03 | -5905E-04 |
| -1539E-03 | -1944E-03 | -1479E-03 | -3078E-04 | -4301E-04 | -4301E-04 | -1553E-03 | -5905E-04 |
| T-DIRECTED CURRENTS FOR MODE 3 | -1019E-03 | -3288E-04 | -1967E-03 | -6202E-04 | -1908E-03 | -2609E-06 | -2379E-06 |
| -1019E-03 | -3288E-04 | -1967E-03 | -6202E-04 | -1908E-03 | -1908E-03 | -2609E-06 | -2379E-06 |
| -1019E-03 | -3288E-04 | -1967E-03 | -6202E-04 | -1908E-03 | -1908E-03 | -2609E-06 | -2379E-06 |
| Z-DIRECTED CURRENTS FOR MODE 3 | -1019E-03 | -3288E-04 | -1967E-03 | -6202E-04 | -1908E-03 | -2609E-06 | -2379E-06 |
| -1019E-03 | -3288E-04 | -1967E-03 | -6202E-04 | -1908E-03 | -1908E-03 | -2609E-06 | -2379E-06 |
| -1019E-03 | -3288E-04 | -1967E-03 | -6202E-04 | -1908E-03 | -1908E-03 | -2609E-06 | -2379E-06 |
| T-DIRECTED CURRENTS FOR MODE 3 | -1019E-03 | -3288E-04 | -1967E-03 | -6202E-04 | -1908E-03 | -2609E-06 | -2379E-06 |
| -1019E-03 | -3288E-04 | -1967E-03 | -6202E-04 | -1908E-03 | -1908E-03 | -2609E-06 | -2379E-06 |
| -1019E-03 | -3288E-04 | -1967E-03 | -6202E-04 | -1908E-03 | -1908E-03 | -2609E-06 | -2379E-06 |
| Z-DIRECTED CURRENTS FOR MODE 3 | -1019E-03 | -3288E-04 | -1967E-03 | -6202E-04 | -1908E-03 | -2609E-06 | -2379E-06 |
| -1019E-03 | -3288E-04 | -1967E-03 | -6202E-04 | -1908E-03 | -1908E-03 | -2609E-06 | -2379E-06 |
| -1019E-03 | -3288E-04 | -1967E-03 | -6202E-04 | -1908E-03 | -1908E-03 | -2609E-06 | -2379E-06 |

t and z directed
current
coefficients
for θ -polarized
incident field

Figure 21b. Partial output of BOTSCB for problem 3. (continued)

| BI-STATIC RCS(DB). INCIDENT PHI = 0.0 THETA = 90.0 | | | | | |
|--|-------|-------|-------|----------|----------|
| PHI | THETA | 00 | 00 | 00 | 00 |
| 0.0 | 90.0 | 11.01 | 7.07 | -1184.29 | -1184.29 |
| 4.0 | 90.0 | 11.00 | 7.01 | -1168.23 | -1159.81 |
| 8.0 | 90.0 | 10.97 | 7.02 | -1162.71 | -1153.82 |
| 12.0 | 90.0 | 10.93 | 7.37 | -1150.27 | -1150.27 |
| 16.0 | 90.0 | 10.86 | 7.58 | -1156.69 | -1147.81 |
| 20.0 | 90.0 | 10.78 | 7.83 | -1154.38 | -1146.81 |
| 24.0 | 90.0 | 10.68 | 8.12 | -1152.74 | -1144.81 |
| 28.0 | 90.0 | 10.57 | 8.42 | -1151.07 | -1143.81 |
| 32.0 | 90.0 | 10.45 | 8.72 | -1149.53 | -1142.81 |
| 36.0 | 90.0 | 10.32 | 9.02 | -1148.09 | -1141.81 |
| 40.0 | 90.0 | 10.19 | 9.30 | -1146.72 | -1140.81 |
| 44.0 | 90.0 | 10.05 | 9.56 | -1145.43 | -1139.81 |
| 48.0 | 90.0 | 9.90 | 9.79 | -1144.22 | -1138.81 |
| 52.0 | 90.0 | 9.77 | 9.98 | -1143.07 | -1137.81 |
| 56.0 | 90.0 | 9.64 | 10.12 | -1142.00 | -1136.81 |
| 60.0 | 90.0 | 9.52 | 10.21 | -1141.01 | -1135.81 |
| 64.0 | 90.0 | 9.42 | 10.26 | -1140.09 | -1134.81 |
| 68.0 | 90.0 | 9.33 | 10.24 | -1139.24 | -1133.81 |
| 72.0 | 90.0 | 9.25 | 10.17 | -1138.47 | -1132.81 |
| 76.0 | 90.0 | 9.18 | 10.04 | -1137.77 | -1131.81 |
| 80.0 | 90.0 | 9.12 | 9.84 | -1137.14 | -1130.81 |
| 84.0 | 90.0 | 9.06 | 9.58 | -1136.58 | -1129.81 |
| 88.0 | 90.0 | 9.01 | 9.26 | -1136.09 | -1128.81 |
| 92.0 | 90.0 | 8.95 | 8.87 | -1135.66 | -1127.81 |
| 96.0 | 90.0 | 8.90 | 8.41 | -1135.31 | -1126.81 |
| 100.0 | 90.0 | 8.85 | 7.90 | -1135.02 | -1125.81 |
| 104.0 | 90.0 | 10.82 | 7.35 | -1134.80 | -1124.81 |
| 108.0 | 90.0 | 10.56 | 6.76 | -1134.64 | -1123.81 |
| 112.0 | 90.0 | 10.25 | 6.17 | -1134.56 | -1122.81 |
| 116.0 | 90.0 | 11.33 | 5.61 | -1134.55 | -1121.81 |
| 120.0 | 90.0 | 11.73 | 5.16 | -1134.61 | -1120.81 |
| 124.0 | 90.0 | 12.14 | 4.85 | -1134.73 | -1119.81 |
| 128.0 | 90.0 | 12.58 | 4.73 | -1134.97 | -1118.81 |
| 132.0 | 90.0 | 12.95 | 4.83 | -1135.27 | -1117.81 |
| 136.0 | 90.0 | 13.33 | 5.10 | -1135.67 | -1116.81 |
| 140.0 | 90.0 | 13.70 | 5.50 | -1136.16 | -1115.81 |
| 144.0 | 90.0 | 14.05 | 5.98 | -1136.81 | -1114.81 |
| 148.0 | 90.0 | 14.36 | 6.48 | -1137.58 | -1113.81 |
| 152.0 | 90.0 | 14.63 | 6.97 | -1138.51 | -1112.81 |
| 156.0 | 90.0 | 14.86 | 7.41 | -1139.66 | -1111.81 |
| 160.0 | 90.0 | 15.11 | 7.80 | -1141.08 | -1110.81 |
| 164.0 | 90.0 | 15.38 | 8.12 | -1142.88 | -1109.81 |
| 168.0 | 90.0 | 15.63 | 8.38 | -1145.28 | -1108.81 |
| 172.0 | 90.0 | 15.85 | 8.58 | -1148.72 | -1107.81 |
| 176.0 | 90.0 | 16.04 | 8.67 | -1154.66 | -1106.81 |
| 180.0 | 90.0 | 16.21 | 8.71 | -1192.62 | -1105.81 |

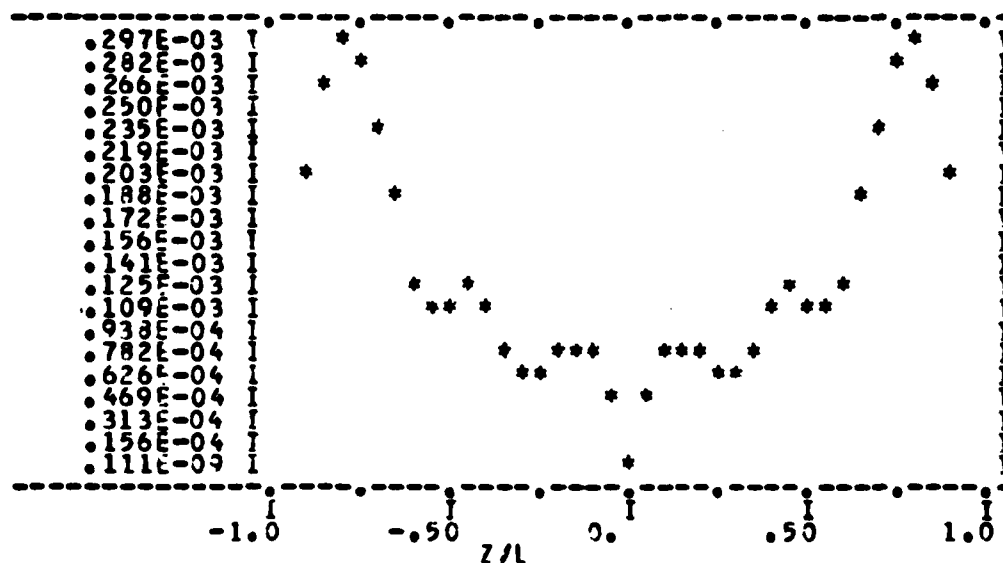
Roll plane
($\theta = 90^\circ$)

0775-0451-07

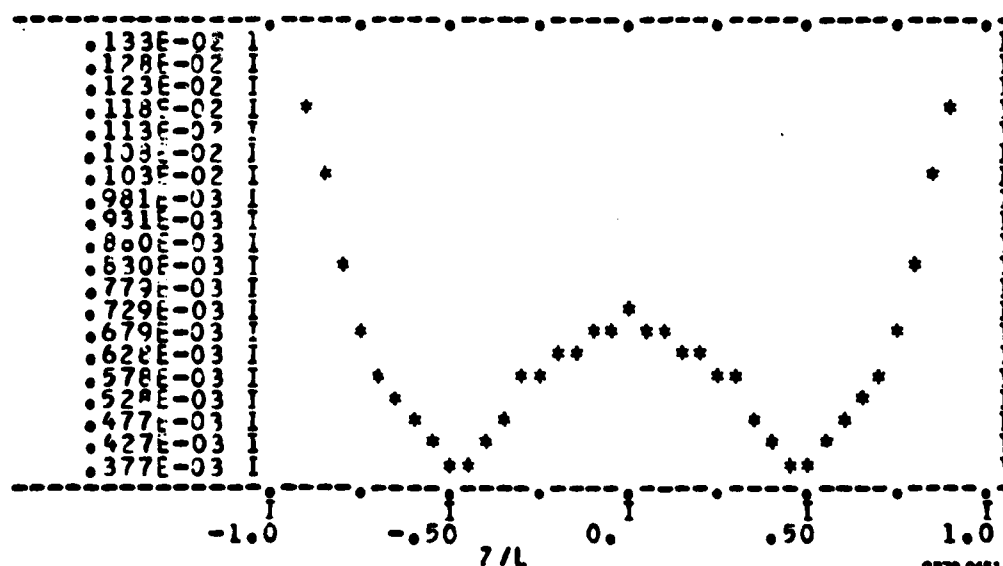
Figure 21b. Partial output of BOTSCB for problem 3. (continued)

Plots of current along BOT for
 θ -polarized incident field.

T-DIRECTED CURRENTS ON TRIANGLE FUNCTION 1



Z-DIRECTED CURRENTS ON TRIANGLE FUNCTION 1



GP73-0451-05

Figure 21b. Partial output of BOTSCB for problem 3. (concluded)

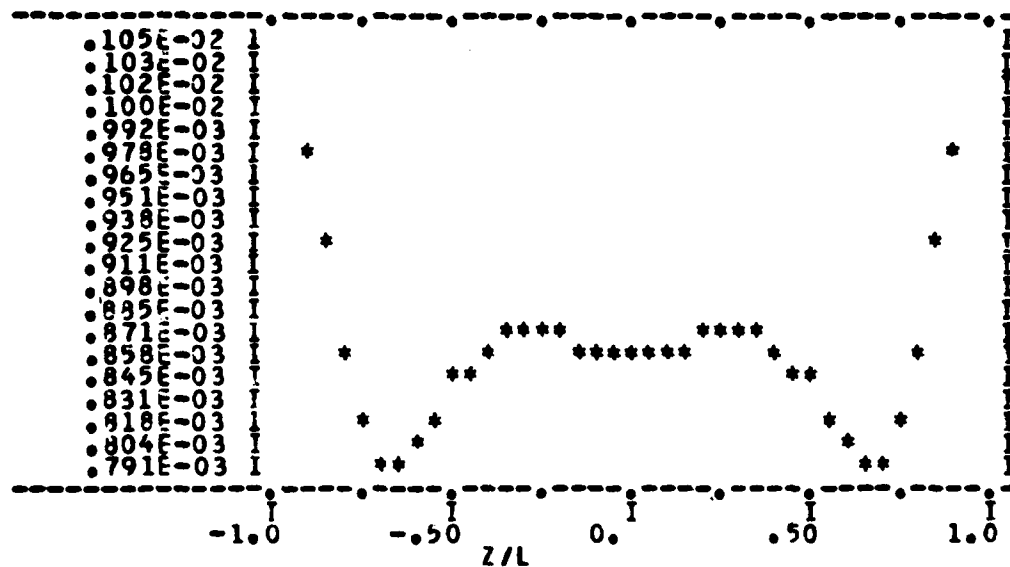
PHI POLARIZED INCIDENT FIELD

| | T-DIRECTED CURRENTS FOR MODE -3 | -1721E-04 | -1033E-03 | 1472E-03 | -1348E-03 | -2815E-03 | -1443E-03 | -3156E-03 | t and z directed current coefficients for phi-polarized incident field |
|---------------------------------|---------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|--|
| | | | | | | | | | |
| | -1350E-03 | -2796E-03 | 1466E-03 | -1625E-04 | -1040E-03 | -1443E-03 | -3156E-03 | -2498E-03 | |
| Z-DIRECTED CURRENTS FOR MODE -3 | | | | | | | | | |
| -5576E-04 | -3008E-03 | -1421E-03 | -1671E-03 | -5754E-04 | -1999E-03 | -3224E-03 | -3703E-05 | -2286E-05 | |
| -5005E-04 | -1942E-03 | -1408E-03 | -1721E-03 | -5542E-04 | -2952E-03 | -2727E-03 | -3703E-05 | -2286E-05 | |
| T-DIRECTED CURRENTS FOR MODE -2 | | | | | | | | | |
| -7333E-04 | -2024E-03 | -1295E-03 | -1329E-03 | -2062E-04 | -3382E-03 | -2149E-03 | -3711E-03 | -3672E-03 | |
| -2068E-03 | -3364E-03 | -1314E-03 | -1314E-03 | -7086E-04 | -2032E-03 | -1940E-03 | -3672E-03 | -3672E-03 | |
| Z-DIRECTED CURRENTS FOR MODE -2 | | | | | | | | | |
| -1375E-03 | -3625E-04 | -1588E-03 | -1350E-03 | -7153E-04 | -9006E-04 | -3725E-06 | -4202E-05 | -4202E-05 | |
| -1109E-04 | -8855E-04 | -1615E-03 | -1350E-03 | -1350E-03 | -3307E-04 | -4711E-06 | -4202E-05 | -4202E-05 | |
| T-DIRECTED CURRENTS FOR MODE -1 | | | | | | | | | |
| -1238E-03 | -2211E-03 | 1272E-03 | 1378E-03 | -2509E-03 | -3482E-03 | -2523E-03 | -3629E-03 | -3674E-03 | |
| -2514E-03 | -3466E-03 | 1305E-03 | 1355E-03 | -1209E-03 | -2229E-03 | -2515E-03 | -3629E-03 | -3674E-03 | |
| Z-DIRECTED CURRENTS FOR MODE -1 | | | | | | | | | |
| -5039E-04 | -2175E-04 | -5841E-04 | -6312E-04 | -1315E-04 | -3562E-04 | -5856E-07 | -2278E-05 | -1555E-05 | |
| -1309E-04 | -3526E-04 | -5841E-04 | -6312E-04 | -1315E-04 | -2034E-04 | -2560E-06 | -2278E-05 | -1555E-05 | |
| T-DIRECTED CURRENTS FOR MODE 0 | | | | | | | | | |
| -1423E-02 | -7439E-03 | -1706E-02 | -3735E-02 | -1569E-02 | -4251E-02 | -3525E-02 | -3525E-02 | -3525E-02 | |
| -1524E-02 | -4238E-02 | -1714E-02 | -3743E-02 | -1501E-02 | -7189E-03 | -1747E-03 | -3525E-02 | -3525E-02 | |
| Z-DIRECTED CURRENTS FOR MODE 0 | | | | | | | | | |
| -1566E-11 | -5271E-12 | 1003E-11 | -5973E-12 | -4159E-13 | 1073E-11 | -7230E-14 | -1346E-14 | -2484E-14 | |
| -2753E-13 | -1079E-11 | -1013E-11 | -5898E-12 | -1355E-11 | 5289E-12 | -8987E-14 | -1346E-14 | -2484E-14 | |
| T-DIRECTED CURRENTS FOR MODE 1 | | | | | | | | | |
| -1238E-03 | -2211E-03 | 1305E-03 | 1378E-03 | -2509E-03 | -3482E-03 | -2523E-03 | -3629E-03 | -3674E-03 | |
| -1524E-02 | -4238E-02 | -1714E-02 | -3743E-02 | -1501E-02 | -7189E-03 | -1747E-03 | -3525E-02 | -3525E-02 | |
| Z-DIRECTED CURRENTS FOR MODE 1 | | | | | | | | | |
| -5039E-04 | -2175E-04 | -5841E-04 | -6312E-04 | -1315E-04 | -3562E-04 | -5856E-07 | -2278E-05 | -1555E-05 | |
| -1309E-04 | -3526E-04 | -5841E-04 | -6312E-04 | -1315E-04 | -2034E-04 | -2560E-06 | -2278E-05 | -1555E-05 | |
| T-DIRECTED CURRENTS FOR MODE 2 | | | | | | | | | |
| -7333E-04 | -2024E-03 | -1295E-03 | -1329E-03 | -2062E-04 | -3382E-03 | -2149E-03 | -3711E-03 | -3672E-03 | |
| -2068E-03 | -3364E-03 | -1314E-03 | -1314E-03 | -7086E-04 | -2032E-03 | -1940E-03 | -3672E-03 | -3672E-03 | |
| Z-DIRECTED CURRENTS FOR MODE 2 | | | | | | | | | |
| -1375E-03 | -3625E-04 | -1588E-03 | -1350E-03 | -7153E-04 | -9006E-04 | -3725E-06 | -4202E-05 | -4202E-05 | |
| -1109E-04 | -8855E-04 | -1615E-03 | -1350E-03 | -1350E-03 | -3307E-04 | -4711E-06 | -4202E-05 | -4202E-05 | |
| T-DIRECTED CURRENTS FOR MODE 3 | | | | | | | | | |
| -1721E-04 | -1033E-03 | 1285E-03 | 1472E-03 | -1348E-03 | -2815E-03 | -1443E-03 | -3156E-03 | -2498E-03 | |
| -1350E-03 | -2796E-03 | 1305E-03 | 1466E-03 | -1625E-04 | -1040E-03 | -1443E-03 | -3156E-03 | -2498E-03 | |
| Z-DIRECTED CURRENTS FOR MODE 3 | | | | | | | | | |
| -5576E-04 | -3008E-03 | -1421E-03 | -1671E-03 | -5754E-04 | -1999E-03 | -3224E-03 | -3703E-05 | -2286E-05 | |
| -5005E-04 | -1942E-03 | -1408E-03 | -1721E-03 | -5542E-04 | -2952E-03 | -2727E-03 | -3703E-05 | -2286E-05 | |

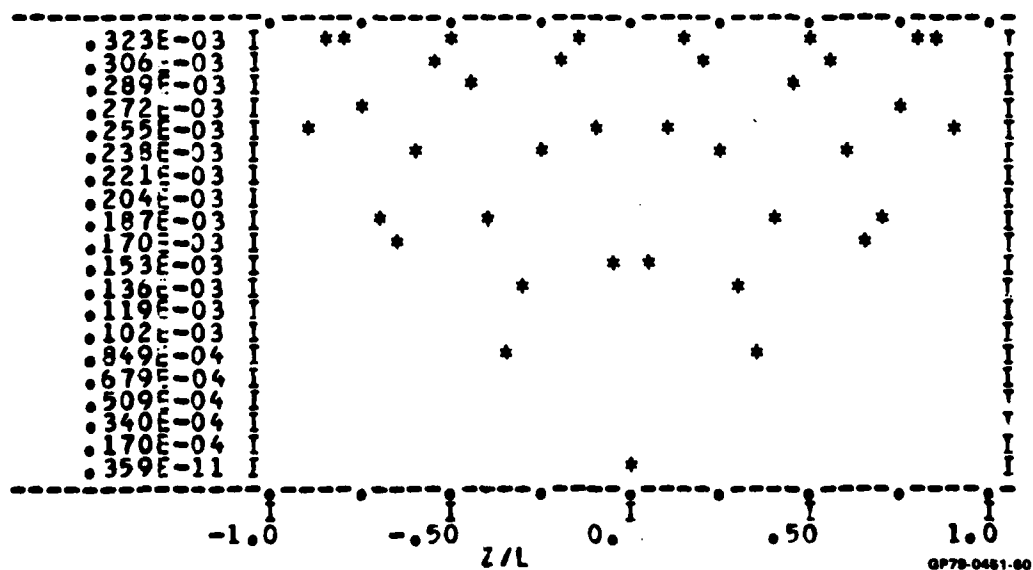
Figure 21c. Partial output of BOTSCB for problem 3.

Plots of currents along BOT for
 ϕ -polarized incident field

T-DIRECTED CURRENTS ON TRIANGLE FUNCTION 1



Z-DIRECTED CURRENTS ON TRIANGLE FUNCTION 1



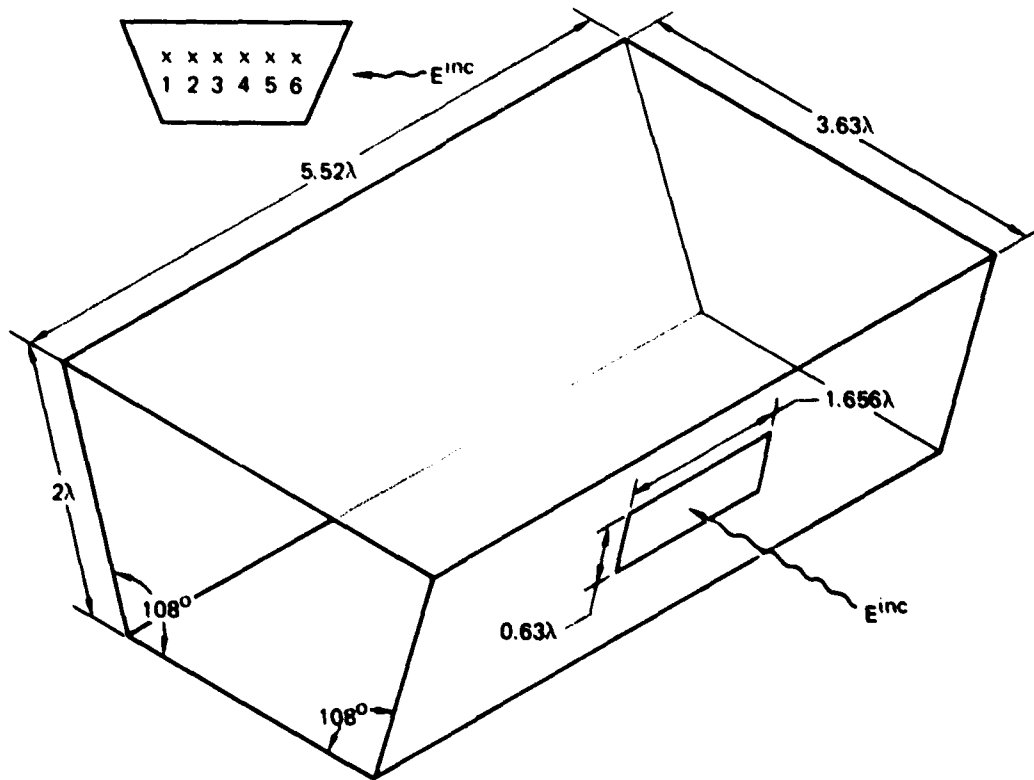
GP78-0481-00

Figure 21c. Partial output of BOTSCB for problem 3. (concluded)

2.6.6 Problem 4

Determine the field penetration into a fuselage equipment compartment represented by a BOT, depicted in Figure 22. Assume that the aperture, centered about $Z = 0$, is 1.656λ in axial length and 0.63λ in width. Let the illumination of the body be broadside ($\theta = 90^\circ$) at 75 MHz in either θ or ϕ polarization. Compute the fields at the following points:

| Sample Point | ZTEST | YTEST | XTEST |
|--------------|-------|--------|-------|
| 1 | 0.0 | 3.8242 | -5.0 |
| 2 | 0.0 | 3.8242 | -3.0 |
| 3 | 0.0 | 3.8242 | -1.0 |
| 4 | 0.0 | 3.8242 | +1.0 |
| 5 | 0.0 | 3.8242 | +3.0 |
| 6 | 0.0 | 3.8242 | +5.0 |



GP79 0481 01

Figure 22. Equipment compartment with aperture.

Solution - The solution was implemented by running BOTZSS, BOTINV, and BOTSCB in sequence. The parameters NP and NMODE were 33 and 4, respectively. The necessary input data to execute the above programs are given in Figure 23, with the partial outputs from BOTZSS, BOTINV, and BOTSCB shown in Figures 24, 25, and 26, respectively. The bistatic scattering cross sections and the currents on the body with the aperture sealed are shown for θ and ϕ illumination in Figures 26b and 26c, respectively. The electric and magnetic field components inside the body at the various sampling points are summarized in Figure 26d.

| | | | | | | | | | | | | | | | | | | | |
|-----|---------|--------------|---------|---------|---------|---------|------------|---------|---------|---------|--|--|--|--|--|--|--|--|--|
| 4 | 14 | | | | | | | | | | | | | | | | | | |
| 36 | 30 | .1570798E+01 | | | | | | | | | | | | | | | | | |
| 0. | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.3833 | 2.6065 | 3.8242 | 5.0419 | 6.2596 | | | | | | | | | |
| 7. | 7.8329 | 7.8329 | 7.8329 | 7.8329 | 7.8329 | 7.8329 | 7.8329 | 7.8329 | 7.8329 | 7.8329 | | | | | | | | | |
| 7. | 7.8329 | 7.8329 | 7.8329 | 7.8329 | 7.8329 | 7.8329 | 7.8329 | 7.8329 | 7.8329 | 7.8329 | | | | | | | | | |
| 0. | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | | | | | | | | | |
| 0. | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | | | | | | | | | |
| -7. | -7.2713 | -7.2713 | -7.2713 | -7.2713 | -7.2713 | -7.2713 | -7.2713 | -7.2713 | -7.2713 | -7.2713 | | | | | | | | | |
| -7. | -7.2713 | -7.2713 | -7.2713 | -7.2713 | -7.2713 | -7.2713 | -7.2713 | -7.2713 | -7.2713 | -7.2713 | | | | | | | | | |
| 2. | 2.5426 | 2.5426 | 2.5426 | 2.5426 | 2.5426 | 2.5426 | 2.5426 | 2.5426 | 2.5426 | 2.5426 | | | | | | | | | |
| 2. | 2.5426 | 2.5426 | 2.5426 | 2.5426 | 2.5426 | 2.5426 | 2.5426 | 2.5426 | 2.5426 | 2.5426 | | | | | | | | | |
| 11. | 11.04 | 11.04 | 11.04 | 11.04 | 11.04 | 11.04 | 11.04 | 11.04 | 11.04 | 11.04 | | | | | | | | | |
| 2. | 2.46 | 2.46 | 2.46 | 2.46 | 2.46 | 2.46 | 2.46 | 2.46 | 2.46 | 2.46 | | | | | | | | | |
| 0. | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | | | | | | | | |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | | | |
| -3. | -3.3120 | 3.3120 | 5.0420 | 6.4194 | 2.6064 | 5.6885 | - Aperture | | | | | | | | | | | | |
| 0. | 0.0000 | 3.8242 | -5.0000 | | | | | | | | | | | | | | | | |
| 0. | 0.0000 | 3.8242 | -5.0000 | | | | | | | | | | | | | | | | |
| 0. | 0.0000 | 3.8242 | -5.0000 | | | | | | | | | | | | | | | | |
| 0. | 0.0000 | 3.8242 | -5.0000 | | | | | | | | | | | | | | | | |
| 0. | 0.0000 | 3.8242 | -5.0000 | | | | | | | | | | | | | | | | |
| 0. | 0.0000 | 3.8242 | -5.0000 | | | | | | | | | | | | | | | | |
| 0. | 0.0000 | 3.8242 | -5.0000 | | | | | | | | | | | | | | | | |
| 0. | 0.0000 | 3.8242 | -5.0000 | | | | | | | | | | | | | | | | |

Primary BOT data set

Scattering angles and incident field

Near-field points

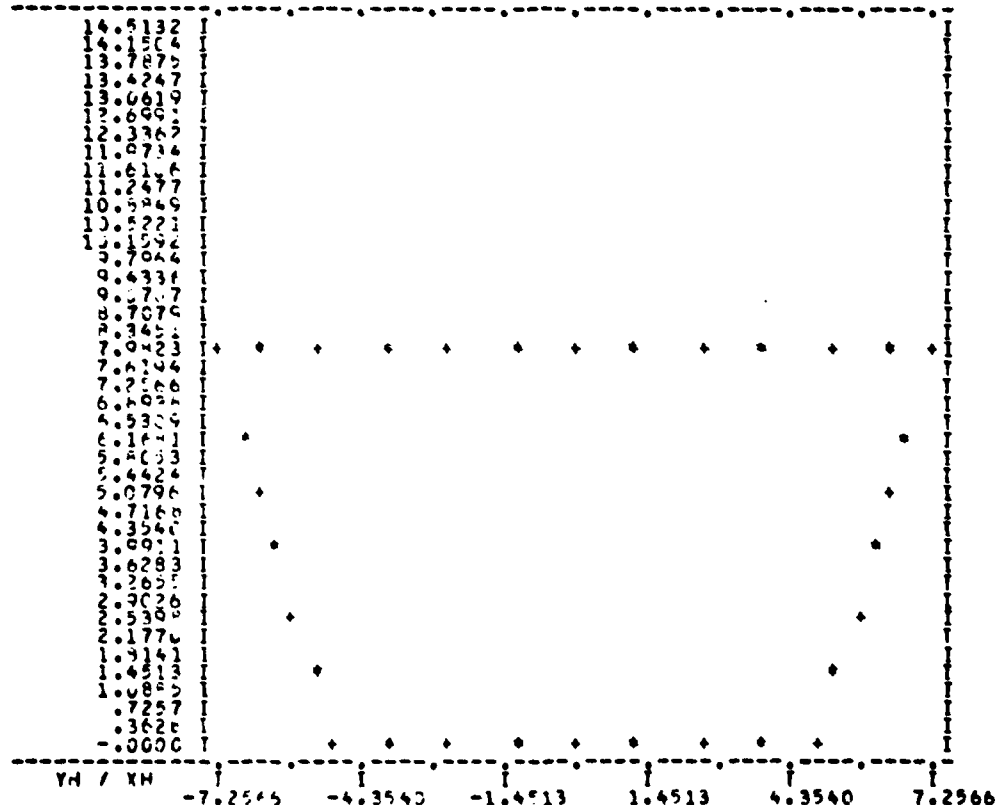
GP79-0481-02

Figure 23. Input data for execution of BOTZSS, BOTINV, and BOTSCB for problem 4.

| NPT 36 | NBAND 14 | NMODE 4 | NP 33 | MC 50 | BK .1570798E+01 |
|-----------|-------------|------------|----------|----------|--------------------|
| Y4 | | | | | |
| 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.3888 |
| 7.8329 | 7.8329 | 7.8329 | 7.8329 | 7.8329 | 2.6765 |
| 7.8329 | 7.8329 | 7.8329 | 7.8329 | 7.8329 | 3.8242 |
| 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 5.0419 |
| | | | | | 6.2596 |

| X4 | | | | | | | | | | |
|---------|---------|---------|---------|---------|---------|---------|---------|----------|----------|----------|
| 0.0000 | -1.2713 | -2.5426 | -3.8139 | -5.0852 | -6.3565 | -7.6278 | -8.8991 | -10.1704 | -11.4417 | -12.7130 |
| -7.2566 | -6.3565 | -5.4564 | -4.5563 | -3.6562 | -2.7561 | -1.8560 | -0.9559 | 0.0441 | 1.1440 | 2.2439 |
| 4.0853 | 6.3565 | 8.6278 | 10.8991 | 13.1704 | 15.4417 | 17.7130 | 19.9843 | 22.2556 | 24.5269 | 26.7982 |
| 2.5426 | 1.2713 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

BODY COORDINATES, + INDICATES TRIANGLE PEAK



HALF-LENGTH OF BOT = 11.3400

0P79-0481-03

Figure 24. Partial output of BOTZSS for problem 4.

| | NP 33 | NMODE 4 | NRAND 14 | | | | | | | | |
|----|----------|------------|-------------|---------|---------|---------|---------|---------|---------|---------|--|
| VM | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.3818 | 2.6065 | 3.8242 | 5.0419 | 6.2596 | |
| | 7.8329 | 7.8329 | 7.8329 | 7.8329 | 7.8329 | 7.8329 | 7.8329 | 7.8329 | 7.8329 | 7.8329 | |
| | 7.8329 | 7.8329 | 7.8329 | 6.2596 | 5.0419 | 3.8242 | 2.6065 | 1.3818 | 0.0000 | 0.0000 | |
| | 0.0000 | 0.0000 | 0.0000 | | | | | | | | |
| IM | 0.0000 | -1.2713 | -2.5426 | -3.8139 | -4.9066 | -5.3233 | -5.6886 | -6.0539 | -6.4193 | -6.7846 | |
| | -7.2596 | -6.4193 | -5.0853 | -3.8139 | -2.5426 | -1.2713 | 0.0000 | 1.2713 | 2.5426 | 3.8139 | |
| | 5.0853 | 6.4193 | 7.2596 | 6.7846 | 6.4193 | 6.0539 | 5.6886 | 5.3233 | 4.9066 | 3.8139 | |
| | 2.5426 | 1.2713 | 0.0000 | | | | | | | | |

THE MINIMUM DIMENSIONS ARE AS FOLLOWS:

| 7 | ZI | WCRK | NZ | LR |
|-------|------|------|----|-----|
| 50174 | 1024 | 0 | 0 | 224 |

Figure 25. Partial output of BOTINV for problem 4.

| | NPT 36 | KRANO 14 | NMODE 4 | NP 33 | PC 50 | RK .1570798E+01 | | | | | |
|----|-----------|-------------|------------|----------|----------|--------------------|---------|---------|---------|---------|--|
| YM | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 1.3388 | 2.6065 | 3.7242 | 5.0419 | 6.7396 | |
| | 7.8329 | 7.8329 | 7.8329 | 7.8329 | 7.8329 | 7.8329 | 7.8329 | 7.8329 | 7.8329 | 7.8329 | |
| | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 3.8262 | 2.6065 | 1.3878 | 0.00000 | 0.00000 | |
| YH | 0.00000 | -1.2713 | -2.3426 | -3.8139 | -4.9066 | -5.3233 | -5.6886 | -6.0539 | -6.4192 | -6.7846 | |
| | -7.7585 | -7.7585 | -7.7585 | -7.7585 | -7.7585 | -7.7585 | -7.7585 | -7.7585 | -7.7585 | -7.7585 | |
| | 7.7585 | 6.2566 | 7.7566 | 6.7846 | 6.4193 | 6.0539 | 5.6886 | 5.3233 | 4.9066 | 4.5193 | |
| | 2.5426 | 1.2713 | 0.7000 | | | | | | | | |

HALF-LENGTH OF NOT = 11.8400

NUMBER OF FIXED ANGLES = 2

NUMBER OF ANGLES PER FIXED ANGLE = 46

FIXED ANGLE CODE(PMT FIXED = 1, THETA FIXED = 2)

0:0

1

M = -2 N = -3

Y .2007121E-02 .4294567E-02 -.1391407E-02 -.4017125E-02

M = -2 N = -3

Y .1234457E-02 -.1739611E-02 -.1461093E-02 .1694495E-02

M = -1 N = -3

Y -.7548029E-03 .1369623E-02 .8610696E-03 -.1764666E-03

M = 0 N = -3

Y .2974443E-03 -.1563840E-03 -.3636430E-03 .2699968E-03

0770-0481-05

Figure 26a. Partial output of BOTSCB for problem 4.

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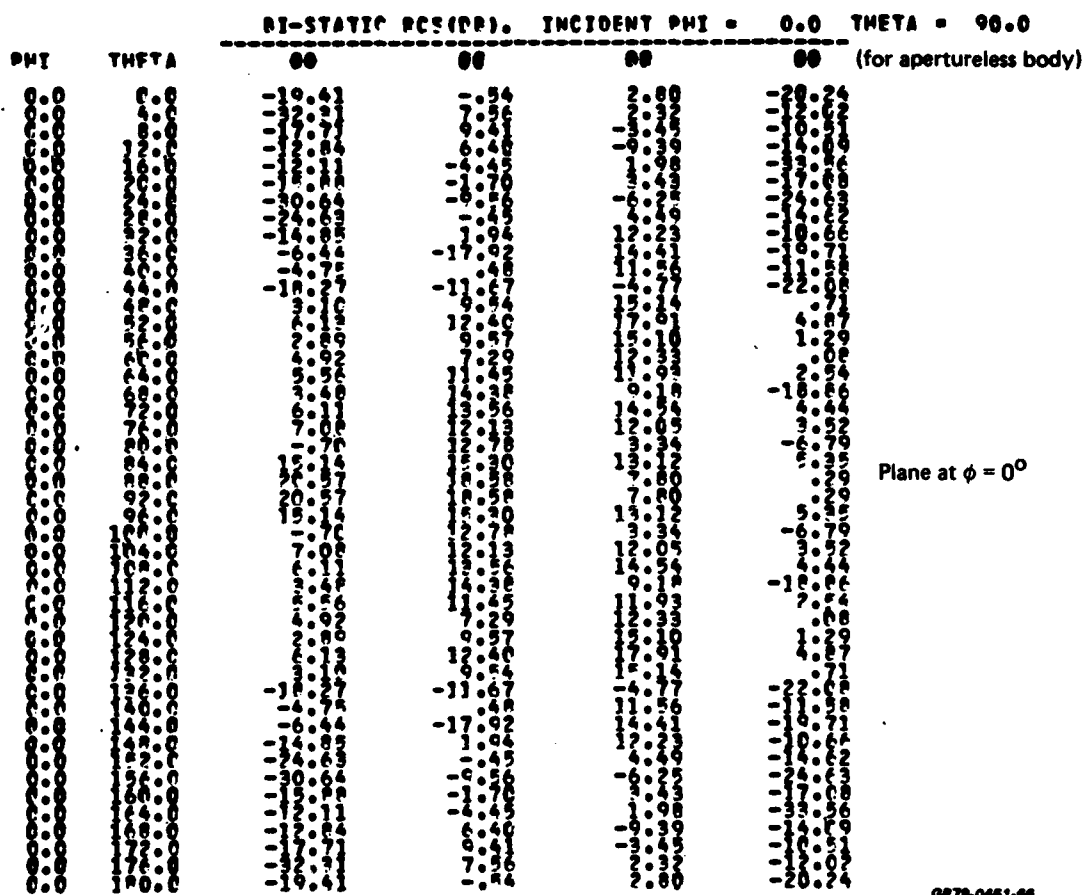


Figure 26b. Partial output of BOTSCB for problem 4.

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CONCLUSIONS OF THE NATIONAL BUREAU OF STANDARDS
AND SHOULD NOT BE USED TO PROMOTE OR CONTRADICT
ANY PRODUCT OR TO ENDORSE OR DISPARAGE ANY
PARTICULAR PRODUCT OR COMPANY

| | | | | | | | |
|--------------------------------|------------|------------|------------|------------|------------|------------|------------|
| -.4239E-03 | .1250E-03 | -.1470E-03 | -.7657E-04 | .7311E-03 | -.3497E-03 | -.4910E-03 | -.7210E-03 |
| -.1041E-03 | .1250E-03 | -.1470E-03 | -.9611E-04 | .7311E-03 | -.3497E-03 | -.4910E-03 | -.7210E-03 |
| -.3710E-03 | .1250E-03 | -.1470E-03 | -.7311E-04 | .7311E-03 | -.3497E-03 | -.4910E-03 | -.7210E-03 |
| 7-DIRECTED CURRENTS FOR NODE 2 | | | | | | | |
| -.4640E-04 | -.2844E-04 | -.4239E-04 | -.1061E-03 | -.3157E-03 | -.3099E-04 | -.7990E-03 | -.4727E-03 |
| -.1703E-04 | -.1723E-04 | -.9739E-04 | -.3077E-04 | -.3157E-03 | -.3099E-04 | -.7990E-03 | -.4727E-03 |
| -.5179E-04 | -.1024E-03 | -.1491E-03 | -.2077E-03 | -.3157E-03 | -.3099E-04 | -.7990E-03 | -.4727E-03 |
| -.3099E-03 | -.2410E-03 | -.1491E-03 | -.2077E-03 | -.3157E-03 | -.3099E-04 | -.7990E-03 | -.4727E-03 |
| 7-DIRECTED CURRENTS FOR NODE 3 | | | | | | | |
| -.4640E-04 | -.2844E-04 | -.4239E-04 | -.1061E-03 | -.3157E-03 | -.3099E-04 | -.7990E-03 | -.4727E-03 |
| -.1703E-04 | -.1723E-04 | -.9739E-04 | -.3077E-04 | -.3157E-03 | -.3099E-04 | -.7990E-03 | -.4727E-03 |
| -.5179E-04 | -.1024E-03 | -.1491E-03 | -.2077E-03 | -.3157E-03 | -.3099E-04 | -.7990E-03 | -.4727E-03 |
| -.3099E-03 | -.2410E-03 | -.1491E-03 | -.2077E-03 | -.3157E-03 | -.3099E-04 | -.7990E-03 | -.4727E-03 |
| 7-DIRECTED CURRENTS FOR NODE 4 | | | | | | | |
| -.4640E-04 | -.2844E-04 | -.4239E-04 | -.1061E-03 | -.3157E-03 | -.3099E-04 | -.7990E-03 | -.4727E-03 |
| -.1703E-04 | -.1723E-04 | -.9739E-04 | -.3077E-04 | -.3157E-03 | -.3099E-04 | -.7990E-03 | -.4727E-03 |
| -.5179E-04 | -.1024E-03 | -.1491E-03 | -.2077E-03 | -.3157E-03 | -.3099E-04 | -.7990E-03 | -.4727E-03 |
| -.3099E-03 | -.2410E-03 | -.1491E-03 | -.2077E-03 | -.3157E-03 | -.3099E-04 | -.7990E-03 | -.4727E-03 |

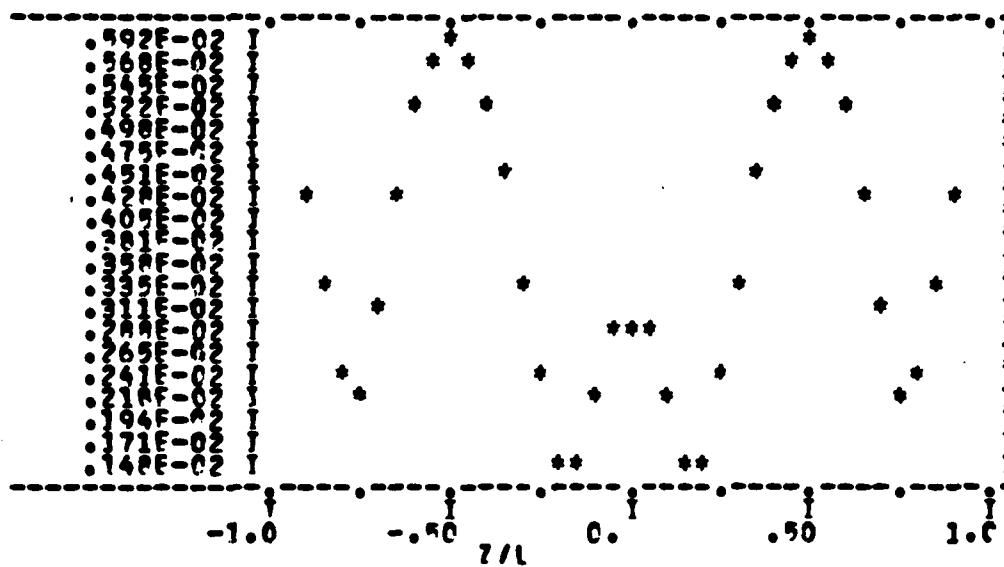
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Figure 26b. Partial output of BOTSCB for problem 4. (continued)

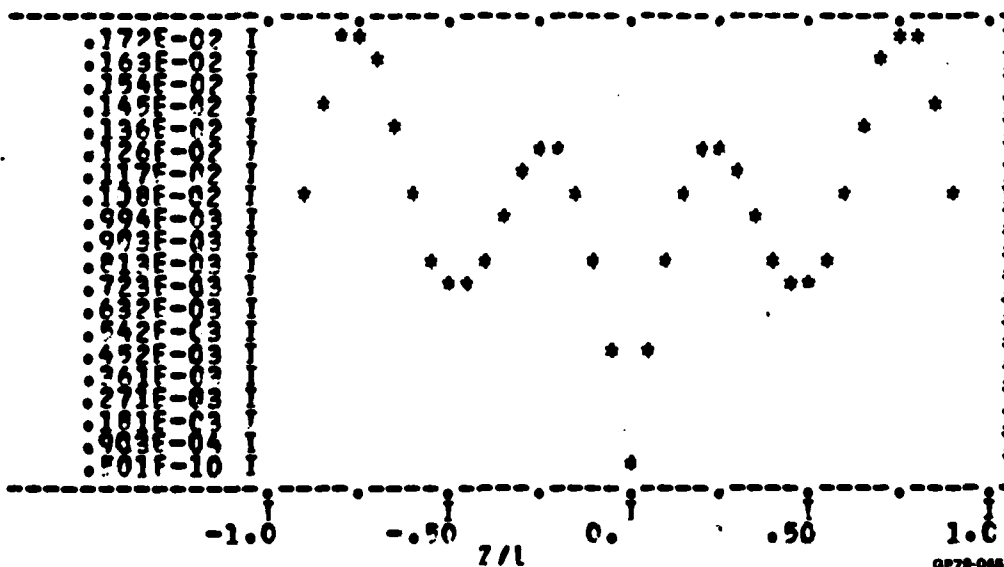
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Plot of currents along BOT for
 θ -polarized incident field

1-DIRECTED CURRENTS ON TRIANGLE FUNCTION 1



2-DIRECTED CURRENTS ON TRIANGLE FUNCTION 1



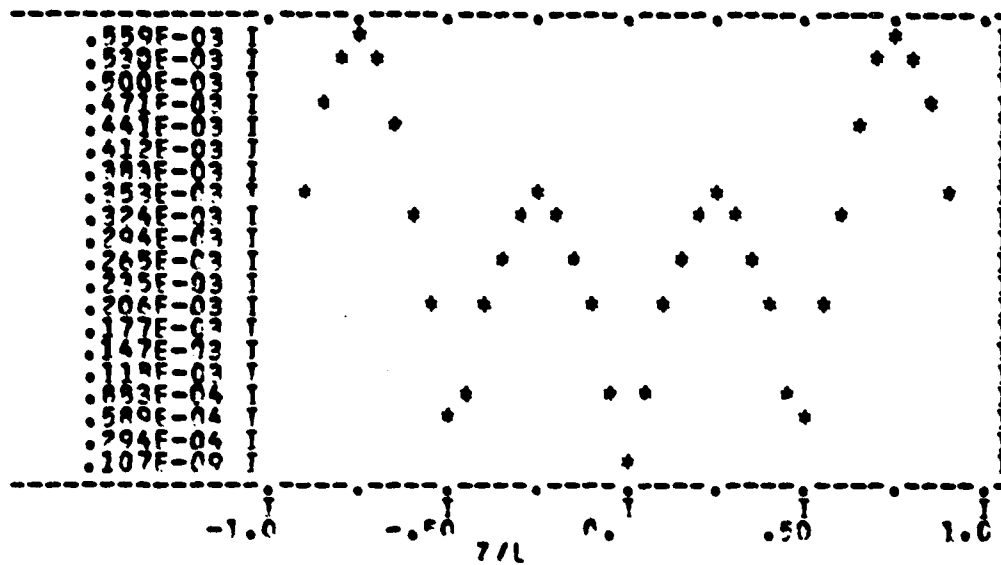
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Figure 28b. Partial output of BOTSCB for problem 4. (concluded)

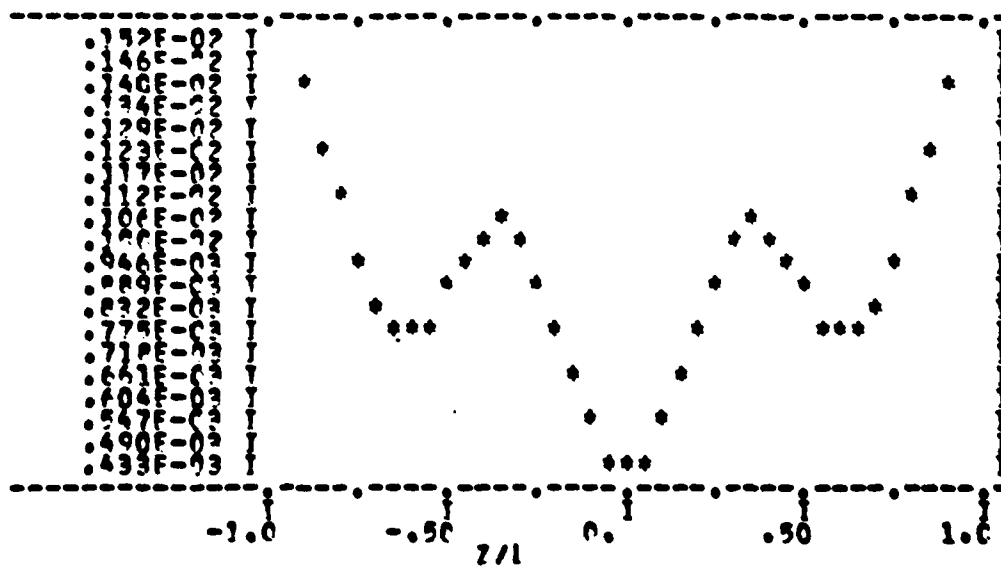
Figure 26c. Partial output of BOTSCB for problem 4. (continued)

Plots of current along BOT for
 ϕ -polarized incident field

6-DIRECTED CURRENTS ON TRIANGLE FUNCTION 1



7-DIRECTED CURRENTS ON TRIANGLE FUNCTION 1



GP79-0481-102

Figure 26c. Partial output of BOTSCB for problem 4. (concluded)

APERTURE ANALYSIS

20 3.3120 3.3120 9.0420 9.0420 2.0000 9.0000 Aperture coordinates

17 17.000 17.000 17.000 17.000 17.000 17.000

17 17.000 17.000 17.000 17.000 17.000 17.000

17 17.000 17.000 17.000 17.000 17.000 17.000

17 17.000 17.000 17.000 17.000 17.000 17.000

Aperture admittance

WEAR FIELD ANALYSIS (for aperture coupled fields)

| E-FIELD | | | | H-FIELD | | | |
|------------------|--------|---------|--------|------------------|---------|---------|---------|
| FIELD COMPONENTS | | | | FIELD COMPONENTS | | | |
| TEST | YTEST | YTEST | YTEST | RADIAL | THETA | PHI | PHI |
| 0.0000 | 3.2242 | -1.0000 | 0.0000 | 17.0000 | 17.0000 | 17.0000 | 17.0000 |
| 0.0000 | 3.2242 | -1.0000 | 0.0000 | 17.0000 | 17.0000 | 17.0000 | 17.0000 |
| 0.0000 | 3.2242 | -1.0000 | 0.0000 | 17.0000 | 17.0000 | 17.0000 | 17.0000 |
| 0.0000 | 3.2242 | -1.0000 | 0.0000 | 17.0000 | 17.0000 | 17.0000 | 17.0000 |
| 0.0000 | 3.2242 | -1.0000 | 0.0000 | 17.0000 | 17.0000 | 17.0000 | 17.0000 |
| 0.0000 | 3.2242 | -1.0000 | 0.0000 | 17.0000 | 17.0000 | 17.0000 | 17.0000 |
| 0.0000 | 3.2242 | -1.0000 | 0.0000 | 17.0000 | 17.0000 | 17.0000 | 17.0000 |

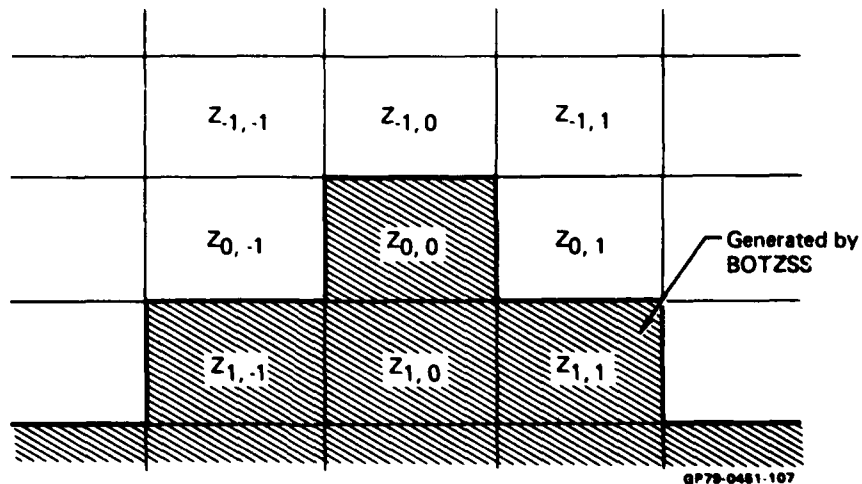
Figure 26d. Partial output of BOTSCB for problem 4.

3. SYSTEMS SECTION: DETAILED PROGRAM DESCRIPTIONS

A detailed description of each main-line MM/BOT program (Figure 1) will be given, including a description of the flow diagram, subroutine input/output arguments, and the special matrix properties used. A description of the common variables used in the program, along with storage methods used in certain arrays, is given in Appendix A. A summary of subroutine calling programs is contained in Appendix B.

3.1 BOTZSS Program

BOTZSS generates the impedance submatrices Z_{mn} for modes m, n where $m = 0$ to $NMODE - 1$, $n = -m$ to $+m$, and $|m - n| < NBAND$. The impedance matrices are generated in the lower triangular portion of Z_{BOT} . Symmetry conditions are then applied in BOTINV in order to fill the entire Z_{BOT} matrix. The structure of the Z_{BOT} matrix is as follows:



where each of the $Z_{m,n}$ matrices is comprised of four submatrices as follows:

| | |
|----------------|----------------|
| $Z_{m,n}^{tt}$ | $Z_{m,n}^{tz}$ |
| $Z_{m,n}^{zt}$ | $Z_{m,n}^{zz}$ |

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F/G 20/14

RADIATION AND SCATTERING FROM BODIES OF TRANSLATION. VOLUME II.--ETC(U)

APR 80 L N MEDGYESI-MITSCHANG; J M PUTNAM

F30602-77-C-0233

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RADC-TR-80-142-VOL-2

NL

2 2
3 1 4



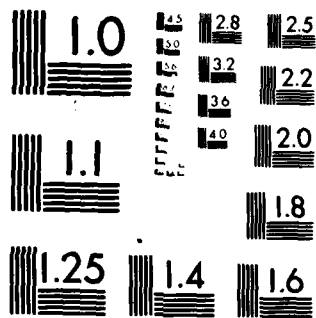
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Figure 27 shows the flow diagram for BOTZSS. The equation numbers refer to the theoretical expressions in Volume I.

The computation of the Green's function kernel takes advantage of the fact that $G_{m,n}$ is symmetric (i.e., $G_{m,n} = {}^t G_{m,n}$), where t indicates the transpose operation. Only the upper triangular portion is stored as indicated in the appendix; hence, $(G_{m,n})_{i,j}$ is stored in location

$$G(i + (j-1)j/2) \text{ when } i \leq j$$

and

$$G(j + (i-1)i/2) \text{ when } i > j.$$

The section that computes the impedance matrix $Z_{m,n}$ uses the following symmetries:

$$Z_{m,n}^{tt} = {}^t(Z_{m,n}^{tt}),$$

$${}_m {}^t(Z_{m,n}^{tz}) = -{}_n Z_{m,n}^{zt},$$

and

$$Z_{m,n}^{zz} = {}^t(Z_{m,n}^{zz}).$$

Thus, only the upper triangular portion of each of the $Z_{m,n}^{tt}$, $Z_{m,n}^{zt}$, $Z_{m,n}^{tz}$, and $Z_{m,n}^{zz}$ needs to be computed. The remaining portion is filled using the symmetry conditions above.

In Figure 27, (X_p, Y_p) define a point on the BOT, with ν_p being the angle subtended by the x-axis and the BOT generating curve. The parameter $\delta = \Gamma/L$, where L is the half-length of the BOT measured along the z-axis and Γ is the distance between adjacent (X_p, Y_p) points on the BOT generating curve. Note a triangle function subtends 2Γ .

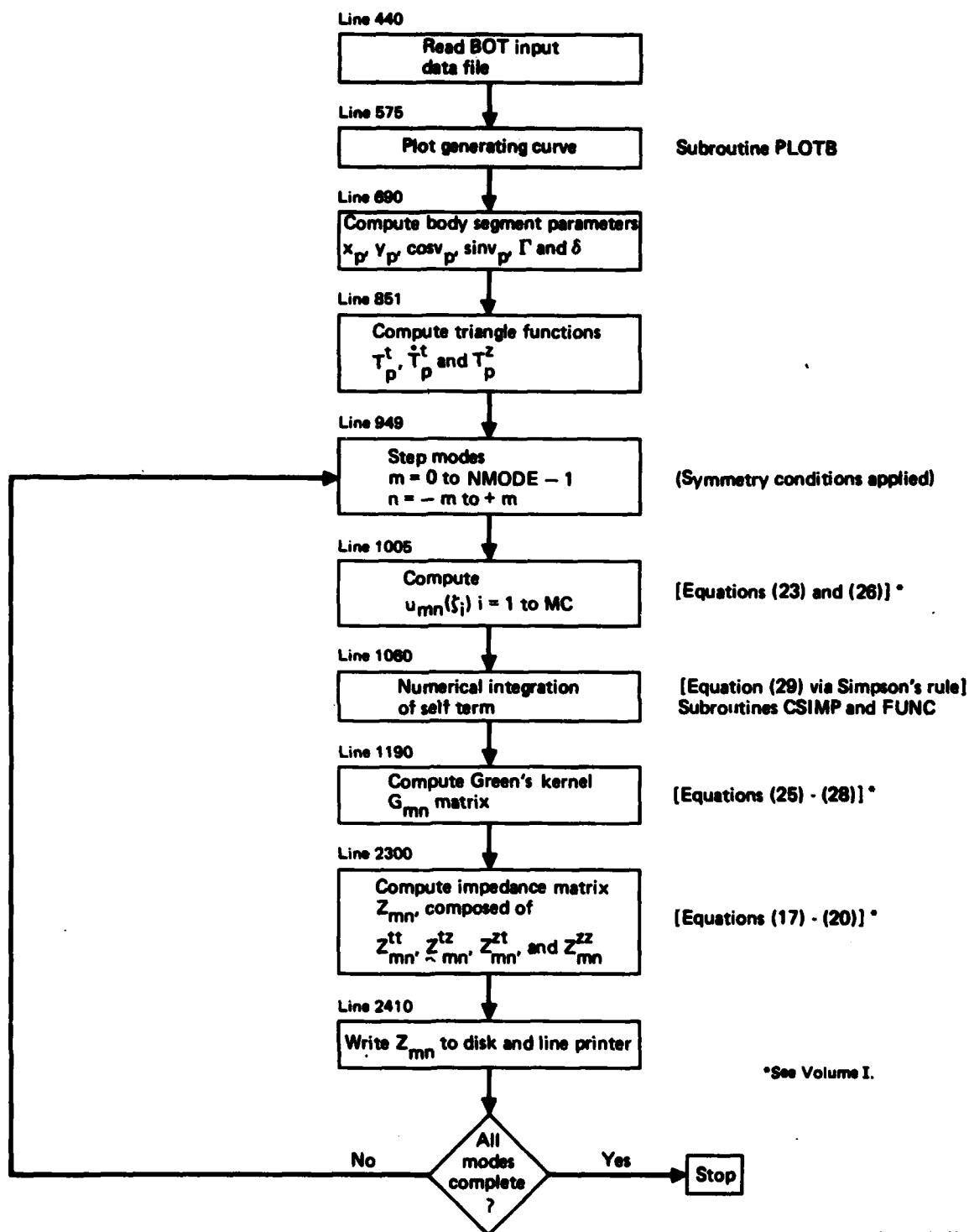


Figure 27. BOTZSS flow diagram.

3.2 BOTZSS Subroutines

3.2.1 Subroutine CSIMP

Subroutine CSIMP is a Simpson integration routine with a calling statement

CALL CSIMP(F,A,B,DEL,IMAX,S11,S,N,IER).

This routine computes $S = \int_A^B F(x)dx$ using the method of successive bisections of the interval until either a relative error of DEL is achieved or IMAX bisections have been performed. F must be declared external in the calling program. The following are returned by CSIMP:

S - Approximate value of the integral.

S11 - Previous approximation to the integral. Convergence has occurred if

$$\left| \frac{S - S11}{S} \right| < DEL.$$

N - Number of intervals used in computing S.

IER - Error return. IER = 0 indicates that convergence has occurred.

3.2.2 Subroutine PLOTB

Subroutine PLOTB plots the points on the generating curve of the BOT. Points on the BOT corresponding to triangle function peaks are indicated with a plus sign. The calling statement is

CALL PLOTB(X,Y,N,NR),

where

X - Array of x coordinates to be plotted

Y - Array of y coordinates to be plotted

N - Number of points to be plotted

NR - Number of line printer rows to use for the y-axis.

The routine uses 51 columns for the x-axis, with the dynamic range on both the x and y axes equal. Hence, depending upon the type of line printer used, NR may have to be adjusted in order to obtain a plot that is not distorted (i.e., the x and y axes have approximately the same physical length on the line printer output).

3.3 BOTINV Program

BOTINV fills the Z_{BOT} matrix using the output file from BOTZSS and inverts this matrix according to the user's specifications. The following symmetries are used to fill Z_{BOT} from the partial Z_{BOT} matrix generated by BOTZSS (see Figure 28 for NMODE = 4):

| <div><div><div>m</div><div>n</div></div></div> | -3 | -2 | -1 | 0 | 1 | 2 | 3 |
|--|---|----|---|---|---|---|---|
| -3 | | | <div><div><div>$z_{3,1}^{tt}$</div><div>$-z_{3,1}^{tz}$</div></div><div><div>$-z_{3,1}^{zt}$</div><div>$z_{3,1}^{zz}$</div></div></div> | | | | |
| -2 | | | $-m, -n$ | | | | |
| -1 | <div><div><div>$z_{3,1}^{tt}$</div><div>$(z_{3,1}^{zt})$</div></div><div><div>$(z_{3,1}^{tz})$</div><div>$z_{3,1}^{zz}$</div></div></div> | | | | | | |
| 0 | $-n, -m$ | | | <div><div><div>$z_{0,0}^{tt}$</div><div>$z_{0,0}^{tz}$</div></div><div><div>$z_{0,0}^{zt}$</div><div>$z_{0,0}^{zz}$</div></div></div> | | | |
| 1 | | | | | | | <div><div><div>$z_{3,1}^{tt}$</div><div>$(z_{3,1}^{zt})$</div></div><div><div>$(z_{3,1}^{tz})$</div><div>$z_{3,1}^{zz}$</div></div></div> |
| 2 | | | | | | | |
| 3 | | | | | <div><div><div>$z_{3,1}^{tt}$</div><div>$z_{3,1}^{tz}$</div></div><div><div>$z_{3,1}^{zt}$</div><div>$z_{3,1}^{zz}$</div></div></div> | | |

Generated by

BOTZSS

Figure 28. Z_{BOT} matrix symmetries.

Main diagonal symmetry

(Compute $Z_{n,m}$ from $Z_{m,n}$)

$$Z_{n,m} = \begin{bmatrix} Z_{n,m}^{tt} & Z_{n,m}^{tz} \\ Z_{n,m}^{zt} & Z_{n,m}^{zz} \end{bmatrix} = \begin{bmatrix} Z_{m,n}^{tt} & -t(Z_{m,n}^{zt}) \\ -t(Z_{m,n}^{tz}) & Z_{m,n}^{zz} \end{bmatrix}$$

Skew symmetry

(Compute $Z_{-n,-m}$ from $Z_{m,n}$)

$$Z_{-n,-m} = \begin{bmatrix} Z_{-n,-m}^{tt} & Z_{-n,-m}^{tz} \\ Z_{-n,-m}^{zt} & Z_{-n,-m}^{zz} \end{bmatrix} = \begin{bmatrix} Z_{m,n}^{tt} & t(Z_{m,n}^{zt}) \\ t(Z_{m,n}^{tz}) & Z_{m,n}^{zz} \end{bmatrix}$$

Figure 29 shows the flow diagram for BOTINV. Three types of matrix inversions are allowed in BOTINV: total inversion, main diagonal inversion, and partial inversion. Each of these options is described next.

Total Inversion - Total inversion is performed when $NBAND \geq 2*NMODE-1$. In this case, the Z_{BOT} matrix is stored by columns as follows:

$$(Z_{m,n}^{tt})_{i,j} = Z((n + NMODE-1)*LS^2*(2*NMODE-1) + (j-1)*(2*NMODE-1)*LS + (m + NMODE-1)*LS + i)$$

$$(Z_{m,n}^{zt})_{i,j} \text{ is stored at } (Z_{m,n}^{tt})_{i,j} + NM$$

$$(Z_{m,n}^{tz})_{i,j} \text{ is stored at } (Z_{m,n}^{tt})_{i,j} + NM*LS*(2*NMODE-1)$$

$$(Z_{m,n}^{zz})_{i,j} \text{ is stored at } (Z_{m,n}^{tz})_{i,j} + NM$$

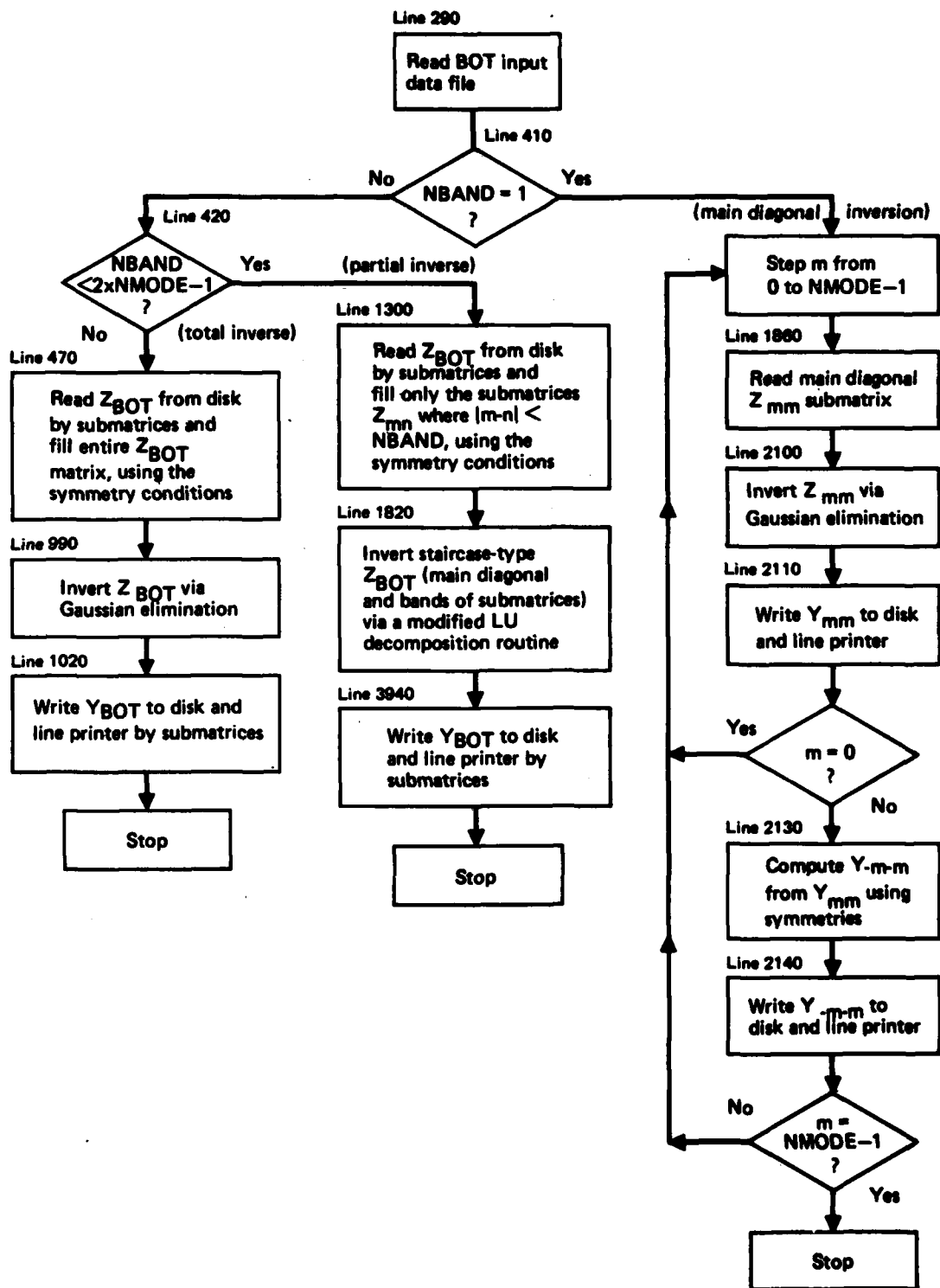


Figure 29. BOTINV flow diagram.

Once the Z_{BOT} matrix is filled, it is inverted using Gaussian elimination with partial pivoting, and written to disk file by submatrices.

Main Diagonal Inversion - Main diagonal inversion is performed when NBAND = 1. In this case, the individual diagonal submatrices are inverted separately using Gaussian elimination. For $m \neq 0$, the following symmetry is used:

$$Z_{-m,-m} = \begin{bmatrix} Z_{-m,-m}^{tt} & Z_{-m,-m}^{tz} \\ Z_{-m,-m}^{zt} & Z_{-m,-m}^{zz} \end{bmatrix} = \begin{bmatrix} Z_{m,m}^{tt} & -Z_{m,m}^{tz} \\ -Z_{m,m}^{zt} & Z_{m,m}^{zz} \end{bmatrix}$$

which implies that

$$(Z_{-m,-m})^{-1} = Y_{-m,-m}$$

has the same symmetries. Thus, at a given time, only $Z_{m,n}$ where $m = 0$ to NMODE-1 is inverted. The symmetries are used, and the resulting $(2*NMODE-1)$ submatrices are written to disk file.

Partial Inversion - Partial inversion is performed when NBAND < 2*NMODE-1, and NBAND ≠ 1. In this case, the Z_{BOT} matrix is filled only with the $Z_{m,n}$ submatrix for which $|m-n| < NBAND$. The resulting Z_{BOT} matrix has a staircase-type structure. The rest of the matrix is sparse. If each of the $Z_{m,n}$ submatrices are thought of as individual elements, Z_{BOT} can be considered as a banded matrix. A modified LU decomposition can then be used with all arithmetic operations replaced by the corresponding matrix operations. The result is an L and U matrix which are also of a staircase-type, but are lower and upper triangular, respectively, when the submatrices are considered as individual elements. The inverse of Z_{BOT} can then be computed using forward and backward substitution, again replacing arithmetic operations with matrix operations. The result is a full inverted Z_{BOT} matrix which is written to disk file by submatrices.

The Z_{BOT} matrix is stored by columns, if the individual submatrices $Z_{m,n}$ are considered as elements. Only the banded portion is stored. When $NMODE = 4$ and $NBAND = 2$ (refer to Figure 28), Z_{BOT} is stored in the following order:

$$Z_{-3,-3}, Z_{-2,-3}, Z_{-3,-2}, Z_{-2,-2}, Z_{-1,-2}, Z_{-2,-1} \dots$$

Each submatrix is stored in LS^2 successive locations by columns. For the example above, $Z_{-2,-3}$ would start at index $LS^2 + 1$.

3.4 BOTINV Subroutines

3.4.1 Subroutine LINEQ

Subroutine LINEQ is a standard matrix inversion routine using Gaussian elimination with partial pivoting, with the following calling statement and arguments:

CALL LINEQ(LL,C,LR),

where

- LL - Order of matrix to be inverted.
- C - Array containing the matrix to be inverted, stored by columns. On output, C contains the inverted matrix.
- LR - Array of length LL used as a work space during the pivoting process.

3.4.2 Subroutine LIST

Subroutine LIST prints individual $Y_{m,n}$ submatrices on the line printer and writes them to a disk file. The calling statement and arguments follow:

CALL LIST(M,N,Z),

where

- M - Index m.
- N - Index n
- Z - Array containing the $Y_{m,n}$ submatrix, stored by columns.

3.4.3 Subroutine INVBAN

Subroutine INVBAN is a modification of a standard banded matrix inversion routine using LU decomposition without pivoting, where only the banded portion is stored by columns. Arithmetic operations were replaced by their corresponding matrix operations, and indices were multiplied by LS^2 since the elements were replaced by matrices. The calling statement and arguments follow:

CALL INVBAN(LS,NMODE,NBAND,NZ,A,Z,WORK),

where LS, NMODE, and NBAND are described in Appendix A.

INPUT: NZ - Array used for indexing. In a normal banded matrix A, $NZ(I) = NZ(I-1) + (\text{the number of zeroes below the band in column } I-1) + (\text{the number of zeroes above the band in column } I)$, where $NZ(1) = 0$. If A has order n, with only the banded portion stored by columns, then A_{ij} will be stored in location $n(j-1) + i - NZ(j)$.

A - Array containing the staircase-type matrix to be inverted, with storage details described above.

Z - Array of length LS^2 used as work area.

WORK - Array of length LS used as work area.

In addition, three variables are passed in common as follows:

COMMON NM,JK(4),LR

where

NM - Number of triangle functions

JK - Work array of length 4

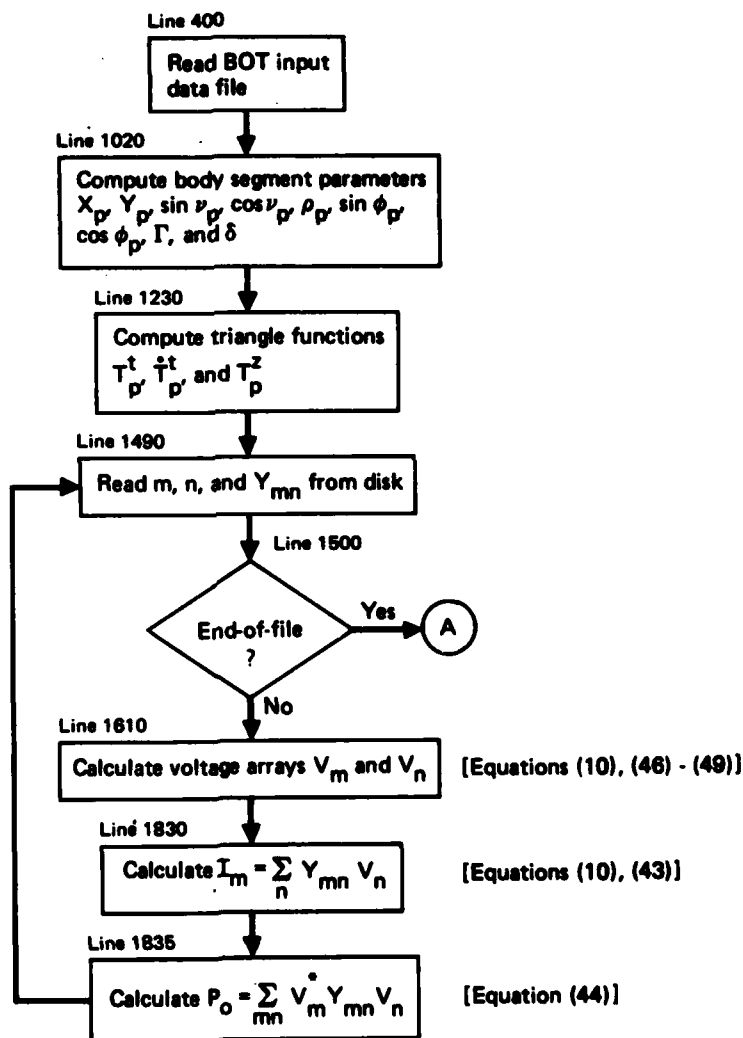
LR - Work array of length LS.

3.4.4 Additional Subroutines

The subroutines MULTS, MULT, REPLACE, and ZERO perform matrix operations which are documented in the listings.

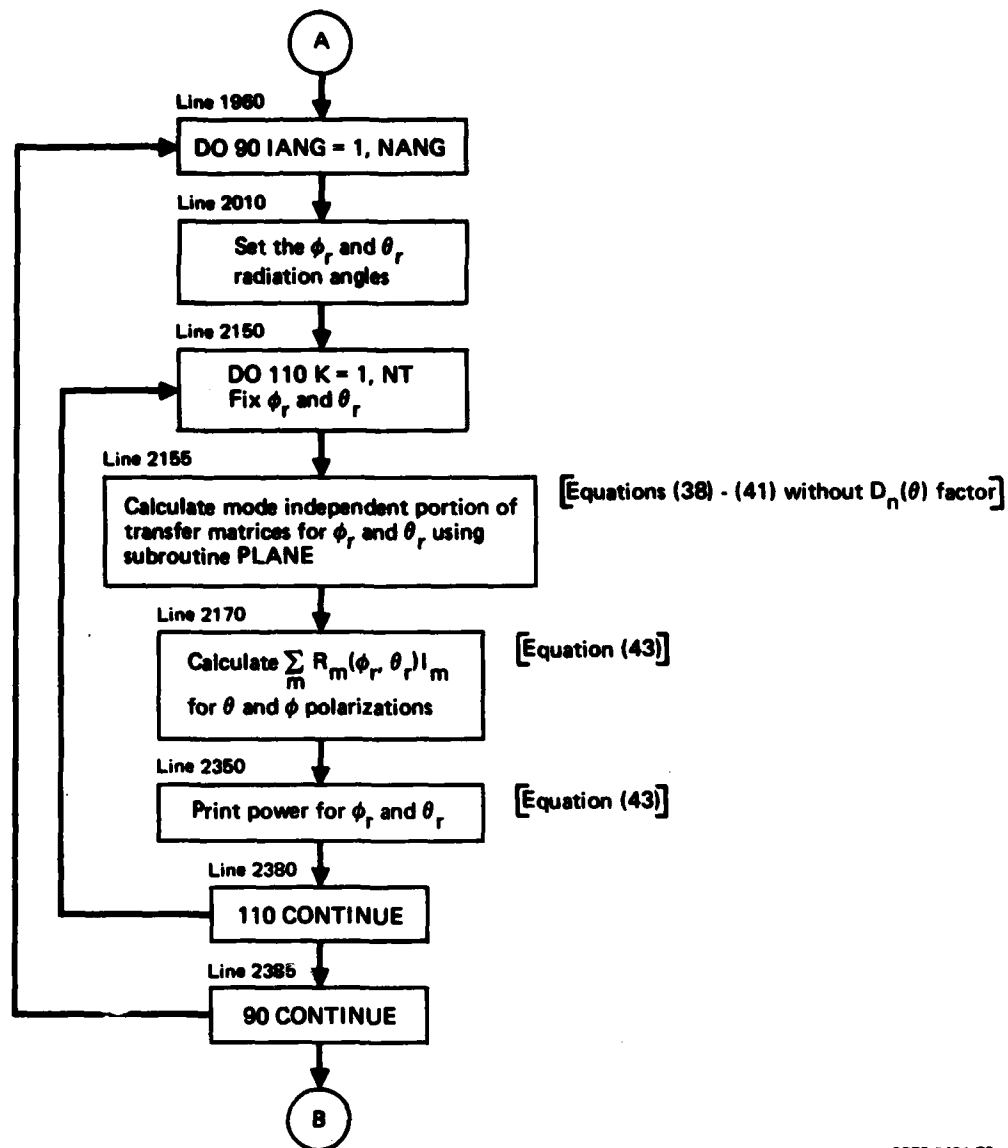
3.5 BOTRA Program

BOTRA computes the radiated far and near fields produced by one or more slot antennas on the BOT (see Section 5 of Volume I). Figure 30 shows the flow diagram for BOTRA with equation numbers referenced to Volume I. The parameters (ρ_p, ϕ_p) define (X_p, Y_p) in cylindrical coordinates.



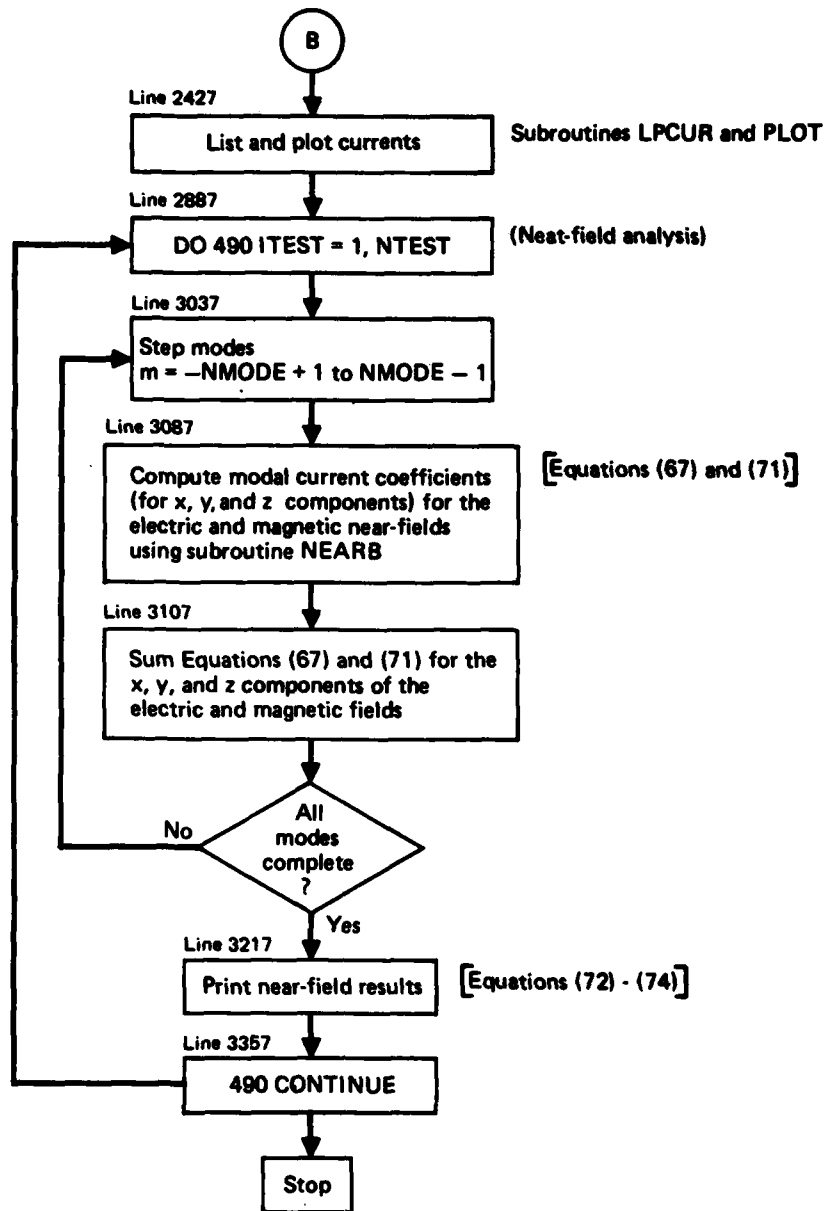
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Figure 30. BOTRA flow diagram.



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Figure 30. BOTRA flow diagram. (continued)



GP79-0481-74

Figure 30. BOTRA flow diagram. (concluded)

3.6 BOTRA Subroutines

3.6.1 Subroutine PLANE

Subroutine PLANE computes the mode independent part of the transfer matrices given in Equations (34-37) of Volume I. The calling statement and argument list is given below:

CALL PLANE(RT,RP,TH,NT,PHI),

where

RT - Array containing the mode independent part of the θ polarized transfer matrices, for NT different angles. See variable RT in Appendix A for storage details.

RP - Array containing the mode independent part of the ϕ polarized transfer matrices, for NT different angles. See variable RP in Appendix A for storage details.

INPUT: TH - Array containing the NT θ angles.

NT - Number of transfer matrices to be calculated, corresponding to the angles in arrays TH and PHI.

PHI - Array containing the NT ϕ angles.

In addition, the body parameters are passed to subroutine PLANE in the common block BODY. The parameters in BODY are described in Appendix A.

3.6.2 Subroutine NEARB

Subroutine NEARB calculates the electric and magnetic modal current coefficients for the near-field calculations (see Section 6 of Volume I). The flow diagram for NEARB is shown in Figure 31. The calling statement and argument list is described below:

CALL NEARB(XTEST,YTEST,ZTEST,ZM),

where

INPUT: XTEST - x coordinate of test point.

YTEST - y coordinate of test point.

ZTEST - z coordinate of test point.

OUTPUT: ZM - Array of modal current coefficients for mode M. Storage details are given in the appendix.

In addition, other variables are passed to NEARB in common blocks BODY, TEST, and INT. These variables are described in Appendix A.

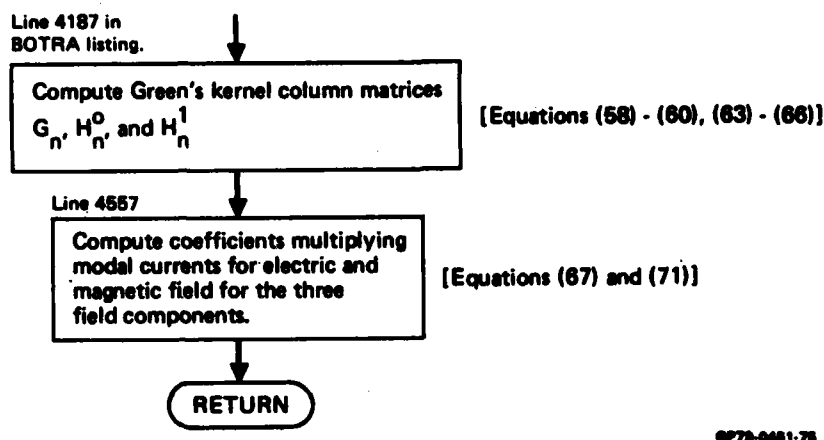


Figure 31. Subroutine NEARB flow diagram.

3.6.3 Subroutine LPCUR

Subroutine LPCUR lists and plots the BOT currents. The entire array of t and z directed modal currents is first printed, followed by plots of the t and z directed currents (magnitude and phase as a function of the normalized z coordinate) for each triangle function on the body. The calling statement and argument list follows:

CALL LPCUR(NMODE,NM,CUR),

where all of the input variables are described in Appendix A.

3.6.4 Subroutine PLOT

Subroutine PLOT plots the magnitude and phase of the currents on a given triangle function. The calling statement is as follows:

CALL PLOT(Y1,Y2),

where

INPUT: Y1 - Array containing the current magnitude at 41 equally spaced z coordinates.

Y2 - Array containing the current phase at 41 equally spaced z coordinates.

3.7 BOTSCM Program

BOTSCM computes scattered far fields in the monostatic mode (see Section 5.2 of Volume I). Figure 32 shows the flow diagram for BOTSCM with equation numbers referenced to Volume I. All of the subroutines called by BOTSCM are described in the BOTRA subroutine section. In the flow diagram, all transfer matrices are computed in one call to PLANE, while in BOTRA and BOTSCM, one transfer matrix is calculated at a time.

3.8 BOTSCB Program

BOTSCB computes scattered far fields in the bistatic mode, after which scattered near fields can be calculated with or without an aperture present. Figure 33 shows the flow diagram for BOTSCB with equation numbers referenced to Volume I.

3.9 BOTSCB Subroutines

Subroutines PLANE, NEARB, LPCUR, and PLOT are described in the BOTRA subroutine section. Subroutine LINEQ is described in the BOTINV subroutine section.

3.9.1 Subroutine APPAR

Subroutine APPAR calculates the aperture parameters LT, VLOW, VHGH, IT, and NAM which are described in Appendix A. These variables are returned in common block S. The calling statement and input parameter list is as follows:

CALL APPAR(XO,YO,X1,Y1,XH,YH,DH,NP,IEDGE),

where

XO, YO, X1, Y1 - Described in the user input section (Section 2).

XH, YH, DH, NP, IEDGE - Described in Appendix A.

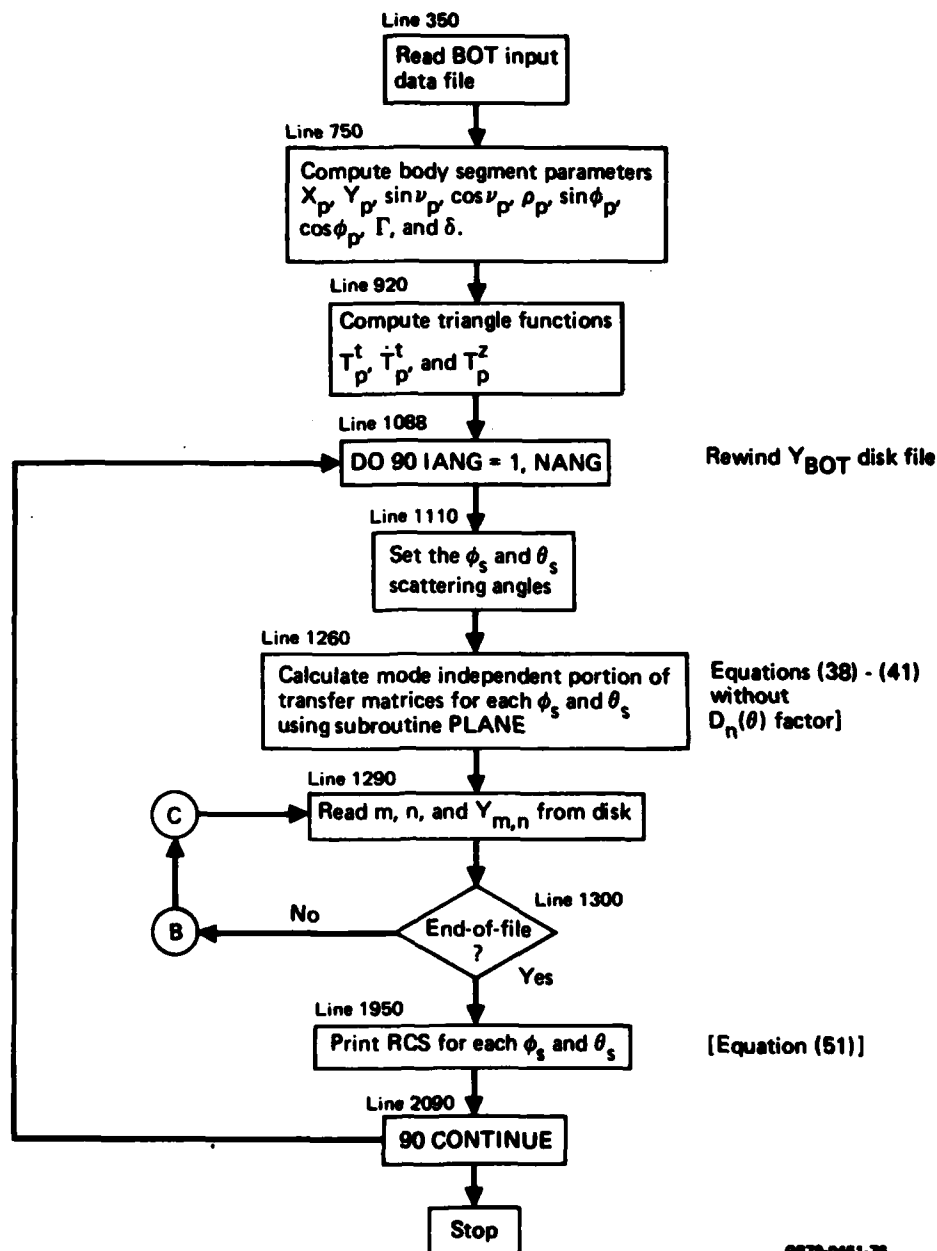


Figure 32. BOTSCM flow diagram.

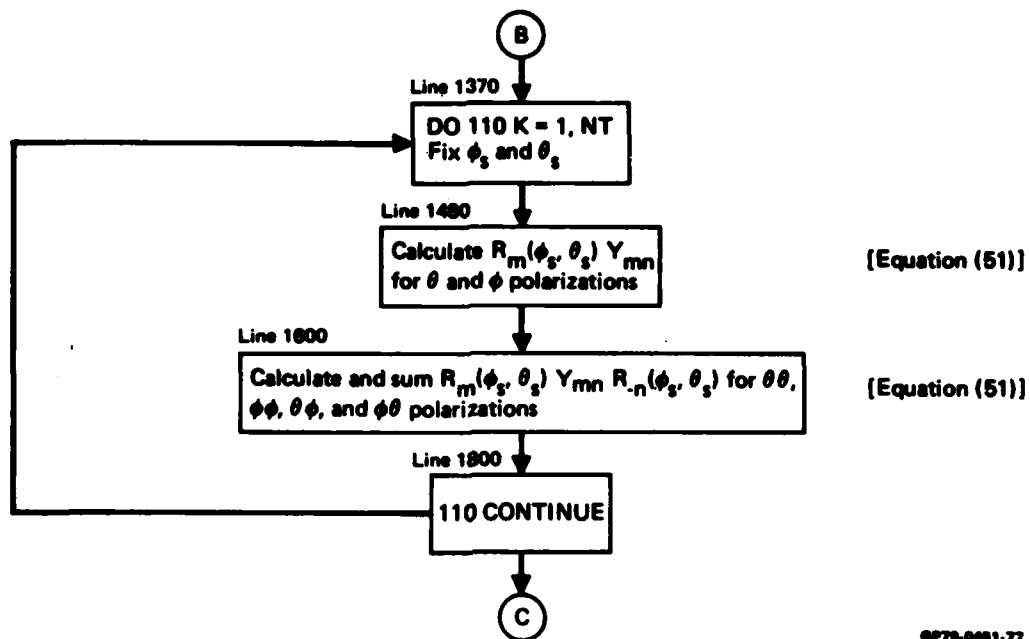


Figure 32. BOTSCM flow diagram. (concluded)

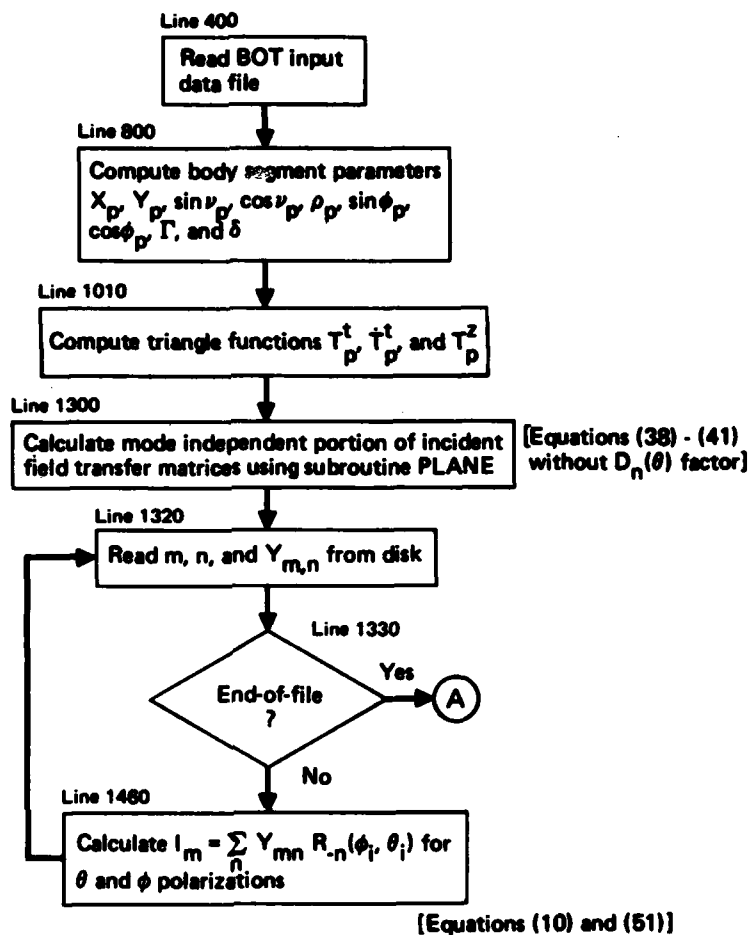


Figure 33. BOTSCB flow diagram.

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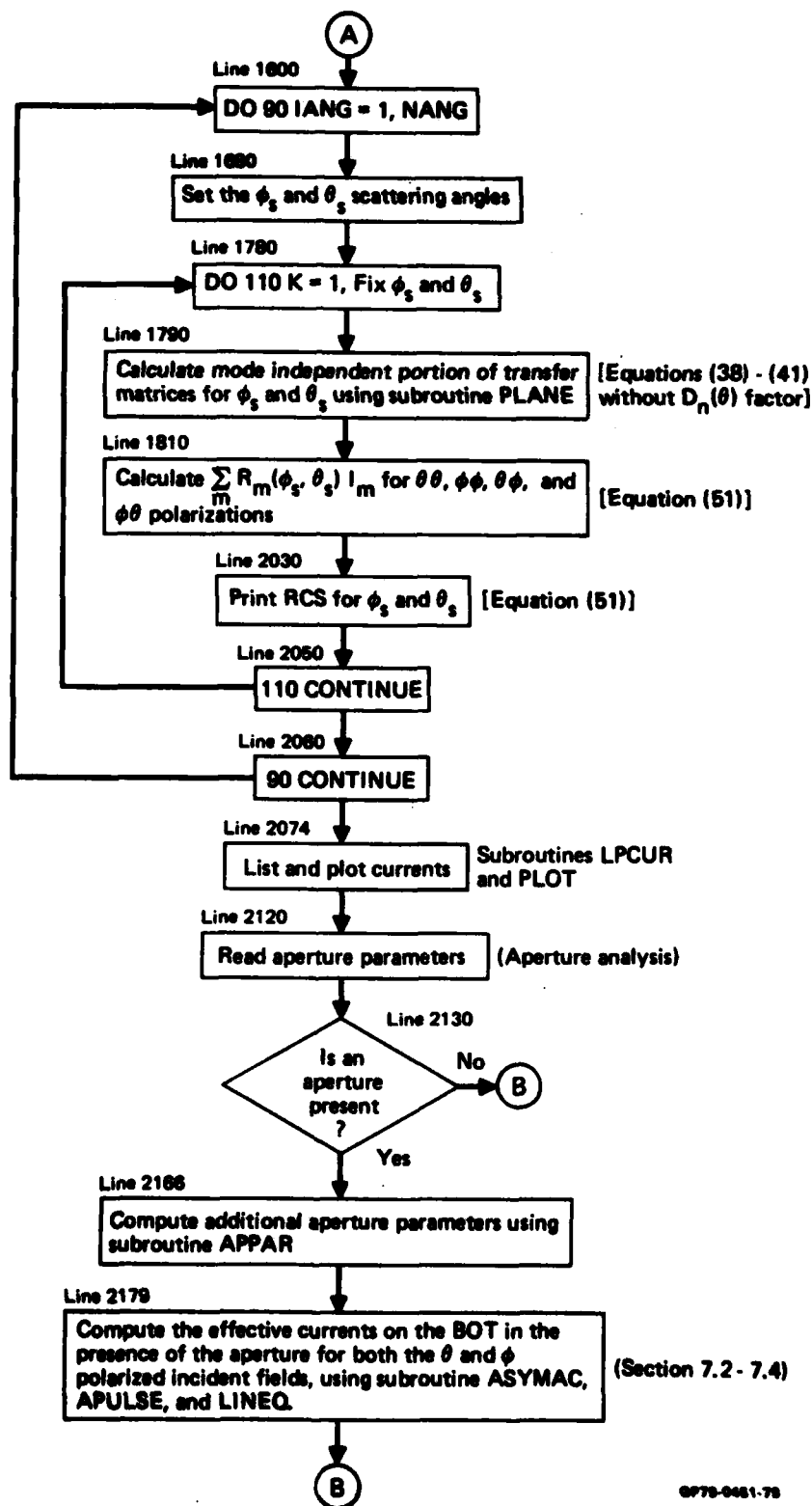
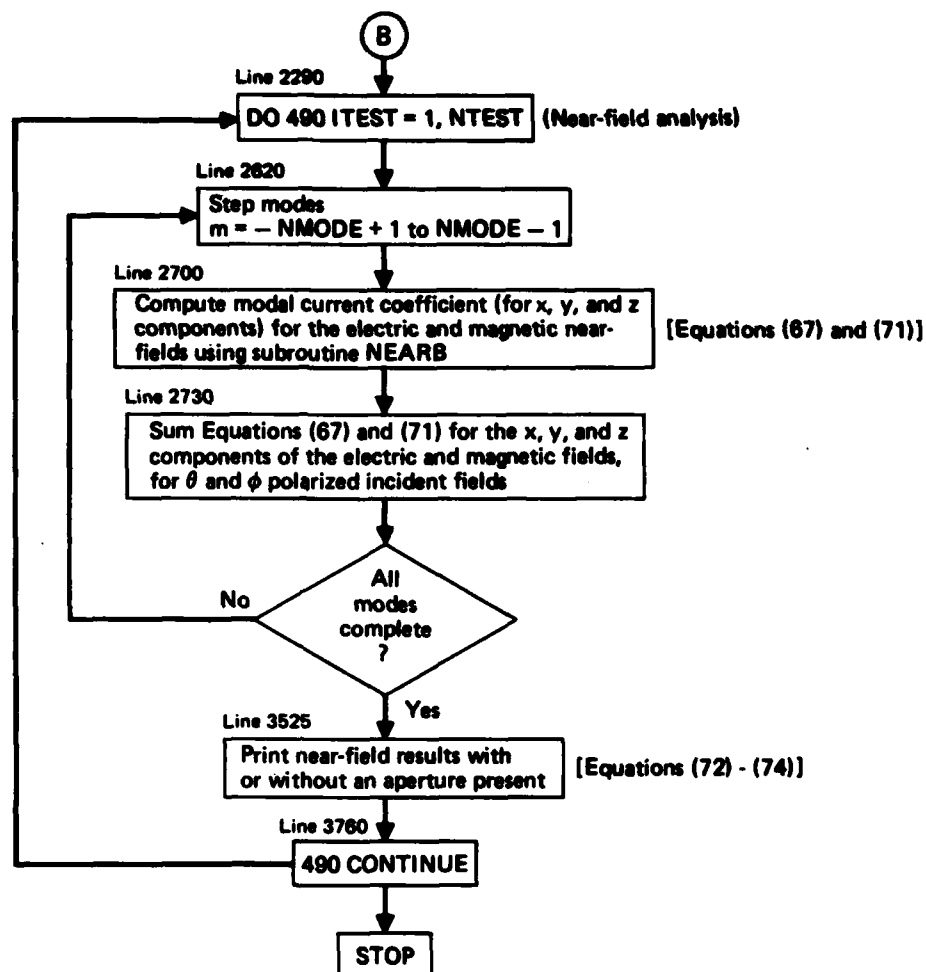


Figure 33. BOTSCB flow diagram. (continued)



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Figure 33. BOTSCB flow diagram. (concluded)

3.9.2 Subroutine APULSE

Subroutine APULSE computes the t - and z -directed aperture pulse functions. The calling statement and argument list is described below:

CALL APPAR(FPP(1,J),FPPZ(1,J),IT(J),LT(J),VLOW(J),VHGH(J),DH),

where

OUTPUT: FPP(1,J),FPP(2,J),FPP(3,J) - The three t -directed aperture pulse functions corresponding to aperture triangle function J are returned in these three successive storage

locations. See variable FPP in the appendix for storage details.

FPPZ(1,J),FPPZ(2,J),FPPZ(3,J) - The three z-directed aperture pulse functions corresponding to aperture triangle function J are returned in these three successive storage locations.

INPUT: IT(J),LT(J),VLOW(J),VHGH(J) - Aperture parameters corresponding to the J-th aperture triangle function, as described in Appendix A.

DH - Array containing BOT segment lengths.

3.9.3 Subroutine ASYMAC

Subroutine ASYMAC computes the equivalent BOT currents in the presence of an asymmetric aperture (the underlying analysis is given in Section 7 of Volume I). The flow diagram for ASYMAC is shown in Figure 34. The calling statement and argument list is described below:

CALL ASYMAC(NMODE,Z0,Z1,Y,CURT,CURP,VT,VP,NM,DH),

where

INPUT: NMODE, Z0, Z1 - Described in user input section.

Y - Work array of length LS^2 used to store the $Y_{m,n}$ submatrices as they are read from disk file.

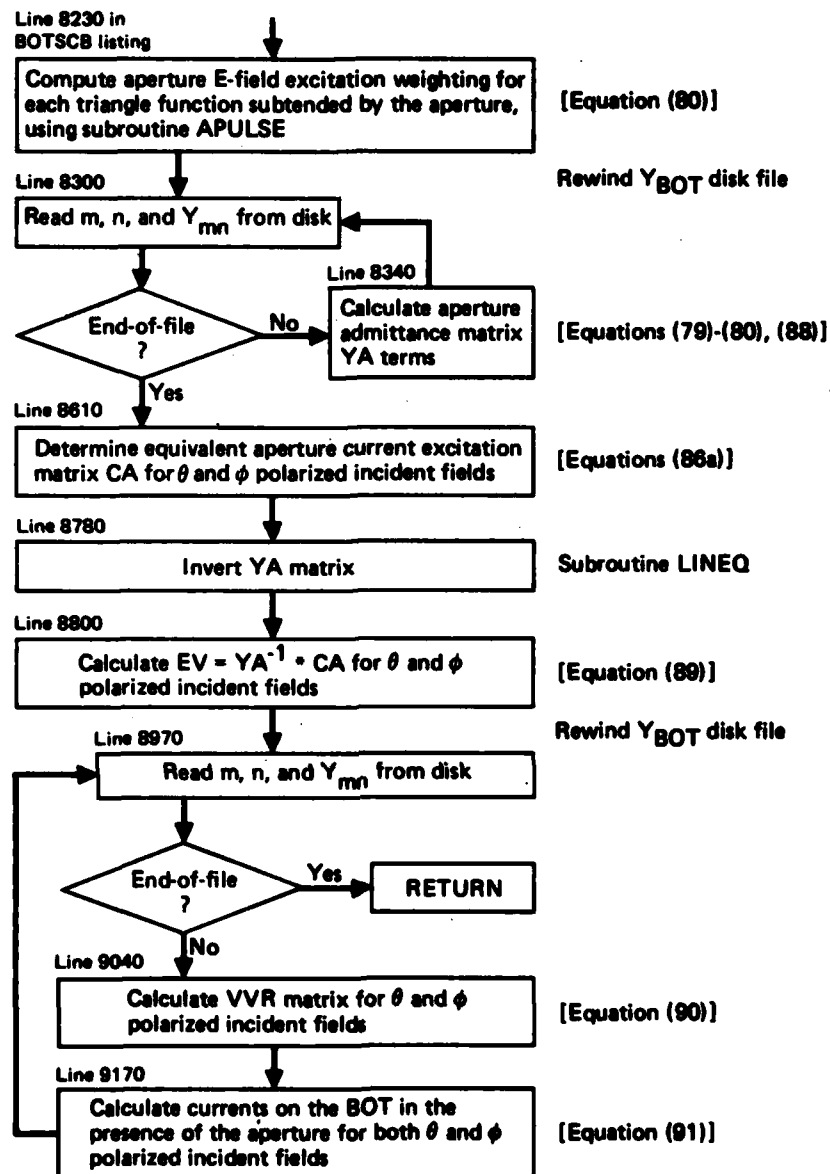
CURT - Array of modal currents (resulting from a θ -polarized incident wave) on the BOT without an aperture present. On returning from ASYMAC, the array CURT will contain the modal currents on the BOT with the aperture present.

CURP - Array of modal currents (resulting from a ϕ -polarized incident wave) on the BOT without an aperture present. On returning from ASYMAC, the array CURP will contain the modal currents on the BOT with the aperture present.

VT - Work array of length LS.

VP - Work array of length LS.

NM, DH - Described in Appendix A.



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Figure 34. Subroutine ASYMAC flow diagram.

APPENDIX A: DICTIONARY OF COMMON PROGRAM VARIABLES

(Input variables are described in Section 2.3; equation numbers refer to expressions in Volume I; page numbers refer to Volume II)

- ANG - Input array of fixed radiation or scattering angles (p. 8).
- BK - Wave number (meters⁻¹).
- BKL - BK*L.
- CAP - Array containing equivalent aperture currents resulting from a ϕ -polarized incident wave [Equation (86)]. CAP(J) contains the t-directed current on the J-th aperture triangle function (i.e., C_{ap}^t). The z-directed current (i.e., C_{ap}^z) is stored in CAP(J + NAM).
- CAT - Array containing equivalent aperture currents resulting from a θ -polarized incident wave [Equation (86)]. See variable CAP for storage details.
- CP(I) - Cosine of ϕ angle for generating curve segment I. (See Figure 5 of Volume I.) Corresponds to $\cos\phi_q$ in Equations (38)-(41).
- CUR - Array containing modal t- and z-directed currents on the BOT [Equation (10)]. CUR [(m + NMODE - 1)*LS + J] contains the t-directed current for mode m on triangle function J. The z-directed current is stored in CUR [(m + NMODE - 1)*LS + J + NM]. Used in BOTRA.
- CURP - Array containing modal t- and z-directed currents on the BOT for a ϕ -polarized incident wave [Equation (10)]. See variable CUR for storage details. Used in BOTSCB.
- CURT - Array containing modal t- and z-directed currents on the BOT for a θ -polarized incident wave [Equation (10)]. See variable CUR for storage details. Used in BOTSCB.
- CV(I) - Cosine of ν_p angle for generating curve segment I. (See Figure 5 of Volume I.) [Equation (17)]. CV(J) corresponds to ν_q on segment J.
- DELTA - GAMMA/L.
- DH(I) - Length of generating curve segment I (meters).
- DTOR - $\pi/180^\circ$.

- ESC - Array containing electric near-field radiation components of $\vec{E}(r')$ in the x, y, and z directions [Equation (67)], stored in ESC(1-3), respectively. Used in BOTRA.
- ESCP - Array containing electric near-field scattering components resulting from a ϕ -polarized incident wave [Equation (67)]. Used in BOTSCB.
- ESCT - Array containing electric near-field scattering components resulting from a θ -polarized incident wave [Equation (67)]. Used in BOTSCB.
- EO - Input array for slot antenna excitation [Equation (46)]. (p. 9)
- ETA - $\eta = \sqrt{\mu_0/\epsilon_0} = 376.707 \Omega$.
- EVP - Array containing aperture E-fields resulting from a ϕ -polarized incident wave [Equation (89)]. EVP(J) contains the t-directed E-field on the J-th aperture triangle function. The z-directed E-field is stored in EVP(J + NAM). $EVP(J) = EV_q^t$; $EVP(J + NAM) = EV_q^z$.
- EVT - Array containing aperture E-fields resulting from a θ -polarized incident wave [Equation (89)]. See variable EVP for storage details.
- FPP - Matrix containing the t-directed pulse functions on the aperture, $F_{j,q}^\alpha$ with $\alpha = t$ [Equation (80)]. FPP(I = 1 to 3, J) contains the three pulse functions $F_{j-1,p}^t$, $F_{j,p}^t$, and $F_{j+1,p}^t$ for the J-th aperture triangle function.
- FPPZ - Matrix containing the z-directed pulse functions on the aperture, $F_{j,q}^\alpha$ with $\alpha = z$ [Equation (80)]. See variable FPP for storage details.
- G - Array containing the integrated Green's function kernel $G_{m,n}$ [Equation (21)]. In BOTZSS, G is symmetric with only the upper triangular portion stored by columns from index 1 to $(NP - 1) * NP/2$. $G_{1,j}$ is stored in location $G[i + (j - 1) * j/2]$ when $i \leq j$.
- GAMMA - Half length of a triangle function base (meters).
- GP - Array containing the fields for the NT radiation angles [Equation (43)] to compute ϕ -polarized gain.
- GT - Array containing the fields for the NT radiation angles [Equation (43)] to compute θ -polarized gain.

- HO - Array containing the integrated Green's function kernel $H_n^0(q)$, ($\gamma = 0$) [Equation (63)] for the magnetic near fields [Equations (63)-(66)].
- H1 - Array containing the integrated Green's function kernel $H_n^1(q)$, ($\gamma = 1$) [Equation (63)] for the magnetic near fields [Equations (63)-(66)].
- HSC - Array containing magnetic near-field radiation components in the x, y, and z directions [Equation (71)]. $HSC = \vec{H}(r')$, used in BOTRA.
- HSCP - Array containing magnetic near-field scattering components resulting from a ϕ -polarized incident wave [Equation (71)]. $HSCP = \vec{H}(r')$, used in BOTSCB.
- HSCT - Array containing magnetic near-field scattering components resulting from a θ -polarized incident wave [Equation (71)]. $HSCT = \vec{H}(r')$, used in BOTSCB.
- IEDGE - Indicates whether the generating curve is open or closed. IEDGE = 0 for closed and 1 for open.
- IPLANE - Input array indicating whether corresponding element of array ANG is a θ or ϕ angle. (p. 8).
- IS - Input array for specifying location of slot antennas. [See Equations (46)-(49).] (p. 9).
- IT(K) - Indicates whether aperture segment K starts or terminates the aperture. $IT = -1$ for the start, $IT = 0$ for interior, and $IT = +1$ for termination.
- KG - $NP - 1$.
- L - Half length of the BOT (meters).
- LS - Order of each $Z_{m,n}$ submatrix. $LS = NP - 3$.
- LSS - $LS * LS$
- LT(K) - Triangle function peak number for aperture segment K.
- M - Mode number m.
- MC - Input variable. M in Equation (26). (p. 7).
- N - Mode number n.
- NAM - Number of triangle function peaks on the aperture portion of the generating curve. NAM should be greater than 1, if an aperture is present.

- NAM2 - NAM*2.
- NANG - Input variable. Number of fixed radiation or scattering angles. (p. 8).
- NBAND - Input variable. Number of submatrix diagonal bands used in Z_{BOT}^{-1} . (p. 7).
- NM - Number of triangle functions on the BOT generating curve. $NM = (NP - 3)/2$.
- NMODE - Input variable. Number of non-negative modes. (p. 6).
- NM2 - Order of each $Z_{m,n}$ submatrix. $NM2 = NP - 3$.
- NM4 - NM*4.
- NP - Number of points on the BOT generating curve. (See Section 2.4.)
- NPT - Input variable. Number of diagonal bands used in impedance matrices. (p. 7).
- NSA - Number of slot antennas on the BOT.
- NT - Input variable. Number of radiation and scattering angles. (p. 8).
- NTEST - Input variable. Number of test points for near-fields. (p. 10).
- PHII - ϕ angle for the incident wave (degrees). $PHII = \phi_i$ in Equation (51).
- PHIR(K) - ϕ angle for the radiated fields (degrees). $PHIR(K) = \phi_r$ in Equation (38).
- PHIS(K) - ϕ angle for the scattered fields (degrees). $PHIS(K) = \phi_s$ in Equation (51).
- R(I) - Distance from origin ρ_q to generating curve segment I (meters) [used in A_q^T in Equations (38)-(41)].
- RP - Array containing the mode independent portion of the $R_n^{t\phi}$ and $R_n^{z\phi}$ matrices (i.e., with the α term removed), resulting from a ϕ -polarized incident wave [Equations (40)-(41)]. The order of storage is
- $$\left\{ (R_n^{t\phi})_1, i = 1 \text{ to } NM \right\} \text{ followed by } \left\{ (R_n^{z\phi})_1, i = 1 \text{ to } NM \right\}$$
- RP may contain the transfer matrices for several (ϕ, θ) angles. In this case, the starting index is off-set by a multiple of $2*NM$.

- RT - Array containing the mode-independent portion of the $R_n^{t\theta}$ and $R_n^{z\theta}$ matrices (i.e., with the α term removed), resulting from a θ -polarized incident wave [Equations (38)-(39)]. The order of storage is
- $$\left\{ (R_n^{t\theta})_1, i = 1 \text{ to } NM \right\} \text{ followed by } \left\{ (R_n^{z\theta})_1, i = 1 \text{ to } NM \right\}$$
- As in RP, the starting index may be off-set by a multiple of $2*NM$.
- SP(I) - Sine of ϕ angle for generating curve segment I. (See Figure 5 of Volume I.) Corresponds to $\sin\phi_q$ in Equations (38), (40).
- SPP - Array containing $\sigma^{\phi\phi}$ for the NT scattering angles [Equation (51)].
- SPT - Array containing $\sigma^{\phi\theta}$ for the NT scattering angles [Equation (51)].
- STP - Array containing $\sigma^{\theta\phi}$ for the NT scattering angles [Equation (51)].
- STT - Array containing $\sigma^{\theta\theta}$ for the NT scattering angles [Equation (51)].
- SV(I) - Sine of ν_p angle for generating curve segment I. (See Figure 5 of Volume I.) [Equation (17).] SV(J) corresponds to ν_q on segment J.
- T - Array containing the values of the triangle functions T_p^t . $T[(K-1)*4 + p]$ contains the values of the k th triangle function over the p -th segment forming it. $1 \leq p \leq 4$. [Equations (17)-(20).] (p. 6).
- TEXC - Input array indicates t-excitation on slot antenna. (p. 9).
- THI - θ angle for the incident wave (degrees). $THI = \theta_i$ in Equation (51).
- THR(K) - θ angle for the radiated fields (degrees). $THR(K) = \theta_r$ in Equation (43).
- THS(K) - θ angle for the scattered fields (degrees) [Equation (51)].
- TP - Array containing the values of T_p^t . The storage method is the same as for T [Equations (17)-(20)]. (p. 6)
- TZ - Array containing the values of T_p^z . The storage method is the same as for T [Equations (17)-(20)].
- U - Imaginary number i .
- UMN - Array containing values of the u_{mn} function [Equation (23)] needed in numerical integration of the Green's function kernel. [See Equation (27).]

- VHGH(I) - Upper "part" width associated with I-th aperture port.
- VLOW(I) - Lower "part" width associated with I-th aperture port.
- VM - Array of voltages corresponding to mode M. VM(K) contains t-directed voltages V_{m1}^t on triangle function K. VM(K + NM) contains z-directed voltages V_{m1}^z on triangle function K [Equation (11)].
- VN - Array of voltages corresponding to mode N. The storage method is the same as for VM [Equation (11)].
- VP - Array containing the equivalent BOT voltages with an aperture present, resulting from a ϕ -polarized incident wave [Equation (90)]. VP(J) is V_{mj}^t and contains the t-directed voltage on the BOT triangle function J. The z-directed voltage V_{mj}^z is stored in VP(J + NM).
- VT - Array containing the equivalent BOT voltages with an aperture present, resulting from a θ -polarized incident wave [Equation (90)]. VT(J) contains the t-directed voltage on the BOT triangle function J. The z-directed voltage is stored in VT(J + NM).
- XO - Starting x coordinate for aperture. (p. 10).
- XI - Ending x coordinate for aperture. (p. 10).
- XH - Input array of x coordinates for BOT. (p. 7).
- XS(I) - x coordinate for generating curve segment I (meters) [Equation (28)].
- XTEST - Input variable for near-field test point x' in r' [Equations (67), (71)]. (p. 10).
- Y - Array containing the $Y_{m,n}$ submatrix [Equations (43), (51)]. In the near-field analysis, however, Y contains the measurement matrix ZM. $Y_{m,n}$ is stored by columns.
- YO - Starting y coordinate for aperture. (p. 10).
- YI - Ending y coordinate for aperture. (p. 10).
- YA - Array containing the aperture admittance matrix, stored by columns [Equation (88)]. YA is of order NAM.
- YH - Input array of y coordinates for BOT. (p. 7).
- YP - Array used as intermediate storage, containing $R_m^{\phi}(\phi_s, \phi_s) Y_{m,n}$ for a given m, n, and scattering angle [Equation (51)].
- YS(I) - y coordinate for generating curve segment I (meters) [Equation (28)].

- YT - Array used as intermediate storage, containing $R_m^{\theta}(\phi_s, \theta_s) Y_{m,n}$ for a given m, n, and scattering angle [Equation (51)].
- YTEST - Input variable for near-field test point y' in r' [Equations (67), (71)]. (p. 10).
- Z - Array containing the $Z_{m,n}$ submatrix [Equations (10), (17)-(20)]. In the program BOTINV, however, Z contains the entire Z_{BOT} matrix. $Z_{m,n}$ is stored by columns.
- ZEXC - Input array [Equation (48)].
- ZM - Array containing the electric and magnetic modal current coefficients for near-field calculations [Equations (67), (71)]. ZM uses the same storage location as the Y matrix, which is of order LS, stored by columns. Rows 1 through 3 of ZM contain the M-th modal current coefficients for the electric near-field components in the x, y, and z, respectively, at the point (XTEST, YTEST, ZTEST). Similarly, rows 4 through 6 of ZM contain the M-th modal current coefficients for the magnetic near-field components in the x, y, and z directions, respectively.
- ZTEST - Input variable for near-field test point z' in r' [Equations (67), (71)]. (p. 10).
- ZO - Input. ZO has different definitions in the programs BOTRA and BOTSCB [Equation (49)]. (p. 10).
- Z1 - Input. Z1 has different definitions in the programs BOTRA and BOTSCB [Equation (49)]. (p. 10).

APPENDIX B: SUBROUTINE CALLING PROGRAMS (BOTZSS, BOTINV, BOTRA, BOTSCB, AND BOTSCM ARE MAIN PROGRAMS)

| Subroutine | Calling program |
|------------|------------------------|
| APPAR | BOTSCB |
| APULSE | ASYMAC |
| ASYMAC | BOTSCB |
| CSIMP | BOTZSS |
| DBCON | BOTRA, BOTSCB, BOTSCM |
| FUNC | CSIMP |
| INVBAN | BOTINV |
| LINEQ | ASYMAC, BOTINV, INVBAN |
| LIST | BOTINV, INVBAN |
| LPCUR | BOTRA, BOTSCB |
| MULT | INVBAN |
| MULTS | INVBAN |
| NEARB | BOTRA, BOTSCB |
| PLANE | BOTRA, BORSCB, BOTSCM |
| PLOT | LPCUR |
| PLOTB | BOTZSS |
| REPLACE | INVBAN |
| SINC | BOTRA, BOTSCB, BOTSCM |
| ZERO | INVBAN |

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